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Major-General the Honourable JAMES LINDSAY, Vice-President, in the Chair.

UTILIZATION OF THE SOLDIER'S UNEMPLOYED TIME—A PROPOSED SCHEME INDEPENDENT OF GOVERNMENT SUPPLY; ALSO A PLAN FOR REGIMENTAL CHARITIES.

By Captain Sloane, Sherwood Foresters Militia.

Now, when it seems probable that for many years to come, peace has settled on the British Army, and that our soldiers have no greater object to look forward to than their daily drill, appears a propitious time for considering the means that are being adopted into the Service for the occupation of the soldier's unemployed time. The improvement of the moral and social condition of the ranks has been, and is, an anxious subject with the authorities; and although many good minds and exalted intellects have given much thought to the matter, yet it has but recently arrived at any practical movement. That the British soldier in time of peace leads the least profitable life to himself and the state, cannot be denied; and that hitherto his unoccupied hours have been spent in vice and recklessness, must be acknowledged with regretful concern. The healthy and energetic years of youth have been too often frittered away, and at a mature age, when habits are confirmed, the soldier returns to civil life, generally without a pension except a temporary one and with at most sixpence, and in rare instances a shilling a day, to begin life again upon, and to seek a new employment for, too often, shattered energies, and a broken constitution; therefore not only the military community, but the nation at large are interested in the subject.

The soldier may be regarded from two points of view. The first, in time of war, when his feelings are aroused, his mind is filled with

thoughts of military glory, and his heart is expanded with a noble and chivalrous love of country; the second, in time of peace, when his sympathies are relaxed, when enthusiasm ceases to animate, when, with the exception of the routine drill, his life is wasted in a purposeless existence. I propose confining my remarks to a consideration of the soldier from the latter point of observation.

To investigate properly the subject before us, we should enter into an inquiry into the habits and condition of the soldier at home, and of his life outside the barrack gate; but I am afraid that that had better not be examined too closely. This remark may seem to bear severely upon our men; yet in reality it is not so, for we must candidly admit the fact, that, owing to our system of military organization, the soldier is nothing more than the machine we make him. We have modelled the soldier in our own mould, but is it just that we should think only of rough casting him for one purpose? Having shaped him out as a material of war, ought we to totally neglect the formation of his moral and intellectual character, exercise no consideration or care except for his fighting qualities, and in every other respect of his existence,

"Let him down the winds to prey at fortune."

I venture to ask this question—Have we been so completely preoccupied in equipping him as an arm of the service, that we have forgotten that he is a human being?

As ours is a country of free enlistment, where the inducements to become a soldier are of a doubtful nature, we are unable to draw into the ranks other than the poorest portion of the population. We have not the aid of conscription to obtain a leaven of the middle classes of society, consequently the raw material of our Army is composed purely and simply of the sons of labour—men whose father's lived by the sweat of their brow, and who themselves were born to no fairer heritage. Thus we get the recruit accustomed to work, and for the first six months we give him plenty of it. The change of life, and the training in his new duties, together with the intellectual contact to which he is exposed, tend to sharpen him in a wonderful degree, so that when he leaves the care of the drill-sergeant, he is fifty per cent. a better man, and enters on his future career full of hope. This would be the proper time to open to him the advantages of his adopted profession. It will clear the way better for what I am about to introduce, should I briefly sketch the soldier from that period.

The soldier joins his company full of energy, cherishing visions of a bright future; but gradually these dreams become clouded, and fade into the fleeting past. The mind, which is at first expanded, sinks into the narrow channel of routine; for, having thoroughly mastered his discipline, he becomes wearied of its continual repetition, for authority repeats it three times a day, in a vain effort to provide him with an occupation. There is no employment for his spare time, and his abilities, be they great or humble, are pent up within himself. But nature must have an outlet. The plant which is not properly trimmed will

run to seed. Thus the young soldier is engrafted with the vitiated habits and associations of his comrades.

The inquiry is naturally suggested, why do the rank and file of our Army happen to be in this condition? The answer is this—because, the supply of men is obtained from the most uneducated and indigent classes. In time of war we have frequently had all the bad characters of our gaols and prisons emptied into the ranks; and these characters, of course, have endeavoured to force their bad habits upon their better-conducted comrades. Moreover, civilization, or what is termed the march of intellect, has failed to reach the soldier, or break through the cordon which his profession draws around him. Another great source of evil is the large amount of time during which the men are left completely to their own resources, the infantry consuming in barren idleness nearly one half the day. Again, how are the soldier's evenings occupied? As a rule, you seldom see the soldier in a place of legitimate amusement. Look at the galleries of a theatre, look at the back seats of a concert room—how many red coats dot these assemblies? The nets are spread to entice and entrap him long before the soldier can reach any place of pure entertainment. The gin palace and the beer-shop are close at hand; seldom can the soldier move ten paces outside the barrack gate without encountering a skittle alley or a tap-room. We are bound to acknowledge it—the soldier is a reckless, unthinking creature; but we are bound to acknowledge also that the fault lies at the door of our own administration. We give him no opportunity for improvement, no subject with which to steady his mind, although we undertake to morally guide him, and to provide for all his necessities. So entirely is he concentrated within his own circle, that all greatre forms and measures for his benefit, to be successful, must develop and work their influence completely within that circle.

The subject I am about to introduce, is nothing new; it is simply an endeavour to collect scattered instances which, having been great successes in particular cases, are now shaped into form, and submitted as a system. What I propose, is to organise a plan in each regiment whereby every industrious soldier may be provided with the means of occupying the hours not engaged on duty with such employment as would be adapted to his capacity, and remunerate him for his labour. If this were the case, a man would lose nothing by enlisting. The skilled artisan, the mechanic, and the tradesman, would not fear the pecuniary loss they now incur by entering the Army.

This subject, which at various times has been mooted, never seemed to meet with anything like a satisfactory solution until in this theatre a most able and ingenious lecture was delivered in April, 1864, by Lieutenant-Colonel Synge, R.E. That officer however confined himself wholly to Government employment of the troops, as the title of his remarks will show—"Military Work by Military Means." Colonel Synge went elaborately into the matter, pointing out the saving that would be effected if Government employed soldiers at fair wages for the construction of forts, fortifications, and military work in general, and laid down such principles as he deemed would be required for such under-

takings. That branch of the subject having been so ably discussed, I shall merely recommend to those interested, a reference to No. 32 of the Journal of this Institution.

There are numerous other branches of labour besides those to which Colonel Synge referred naturally embraced within the description of industrial employments, such as the manufacturing by the men of their own outfitting materials and their own clothing, the repairs of barrack damages, gardening, &c. Were the regimental mechanics allowed to repair barrack damages, a great source of heart-burning in the Army—the stoppages for barrack damages—would be dried up. But many of these employments, I am afraid, would interfere with the interests of the contractors, and we know from experience that that is not to be done with impunity.

However, I pass these subjects without further notice, and restrict myself to the one object, namely, the profitable employment of the soldier within his barrack.

I propose to establish a system thoroughly independent of supplies from Government, or, in fact, contributions from any source. The reason that every plan for utilizing the soldier's time has hitherto fallen through, is that all these efforts have been based on the supposition that the money should come from Government; and it is probable that the War Minister himself would experience as much difficulty in the House in obtaining the adoption of such a measure, as the Chancellor of the Exchequer recently felt in his struggle to finally settle the compound householder.

No doubt a great deal has been done lately, and is being done now, for the soldier's welfare; we have established recreation-rooms, amusements, and classes of instruction of various kinds. At Aldershot, for example, during the last six winter months, 284 entertainments were given, consisting of 209 lectures, 33 concerts, 34 readings, and 8 theatrical representations. Libraries and schools have also been established, though, I am sorry to say, the attendance at the latter has been little more than nominal, for out of the 11,000 infantry soldiers whose names are entered on the school list, the average attendance of each man has been but once a week, notwithstanding all school fees were abolished four years since, as an inducement. The great majority of our soldiers are uneducated, and one-fifth of them can neither read nor write; but although this educational poverty exists, there is not nearly the same deficiency in skilled labour; for examining the previous occupations of 1,000 men, we find that there are 250 mechanics and tradesmen; 132 manufacturing artisans; 106 shopmen and clerks, 7 professional men and students, the remaining 505 being labourers, husbandmen, and servants. Thus, we may say, in round numbers, that there are 400 skilled workmen in the Army, against 600 unskilled, so that if employment could be obtained by the soldiers, something less than one-half the men in the ranks would be able at once to select work of a remunerative character, which they could commence without delay, and by which they could earn good wages.

The fact is, the soldiers want to get started; it is there that the difficulty rests, because there is no guidance, nor direction, no means of

obtaining work, no money to purchase tools to work with. It is obvious, then, that we require some principle on which to begin.

In order to overcome this preliminary difficulty, I propose to establish in every regiment, to direct the management, and to assume the whole control and responsibility of his department, exactly on the same principle as the Instructor of musketry, an Officer-Superintendent, or manager, who may be called the Officer of Industry. As this officer would require peculiar talents and qualifications, totally independent of his military proficiency, I would suggest that the selection should be made by the Field Officers of the regiment assembled as a board, or at least that the officer selected should be recommended for the appointment in that manner. But I may be met with the question —how are you to remunerate this officer? That I shall answer presently. Well, the Officer of Industry having been appointed in the regiment, how does he proceed to work? He reflects, and finds his first thoughts troubled with the great every-day want of the world; that which we live for, work for, fight for, and die for—money. Money is the mainspring of enterprise, and without this mainspring the Officer of Industry will be unable to set his machinery in motion. But he has a large field to work upon, which only requires careful management in order to produce an abundant supply of means for his purposes.

I may be pardoned the digression I here make, in referring to the passing of the estimates for the Army in Parliament. When the Minister of War proposed a grant of £2,000 for the purchase of billiard tables, and the erection of billiard-rooms in barracks, to enable officers to find amusement at home—a grant for which the Service is deeply grateful to him—I have no doubt that had any of the many military members present reminded the Right Hon. Gentleman to set apart a similar sum for the establishment of industrial workshops in barracks, he would probably have acceded to the request, and Parliament have voted the money unanimously.

The means by which the Officer of Industry can obtain money to start his workpeople are various and endless. Nothing is easier than for a regiment to get up an entertainment, whether in the way of field sports, amateur theatricals, lectures, or concerts; in fact we have only to turn to the pages of the military newspapers to see how frequently these performances are given. Every regiment can draw out an attractive programme of field sports, such as athletic feats, prowess of arms, &c. The men who take part in them would be satisfied with small rewards, considering the object and the fun. Then the services of the band would cost nothing, and the printing could be done in the regiment, as every battalion has, or ought to have a portable printing press. Very little expense would be incurred, and almost the whole receipts would accrue as profit. Only in very small country towns where regiments are quartered, would it be impossible by a first exhibition to realize a sum of twenty pounds. I need not call attention to the fact, that garrison amateur performances always draw crowded houses. The public are extremely fond of military music, the band being almost a sufficient attraction; there is, also, the influence of officers amongst their friends to be taken in the account. Another

important consideration—at least with the ladies—is, that military entertainments are fashionable affairs. I say, then, let them be made paying speculations. If in preparing for concerts, or lectures, officers devote a large portion of their time to studying music, or reading up scientific subjects, and junior officers are thereby drawn away from amusements less intellectual, it might be to the advantage of all parties concerned. Persons who have not given the subject consideration may be dubious about the success of such undertakings, or, perhaps, may not be aware how easy a matter it is for a regiment to get up a capital concert. However, having some experience, let me briefly sketch a programme. The band occupies the orchestra, commences with an overture, following with an opening chorus, a few solos being selected for the best instrumentalists; then it is always easy, from seven or eight hundred men, to get some good voices for songs, glees, &c., with an occasional introduction of the comic element, which always goes off well. Here is a well-paying venture—all profit. Other very creditable and profitable undertakings are exhibitions of industrial works; nothing could be more successful, than a display of the kind given by the second battalion of the 12th Regiment at Dublin. The Rotunda—a large public building in that city, was crowded with specimens of work from nearly every branch of trade; and all through the halls, men were employed at their benches—not mere amateurs, or jobbers—but regular mechanics who, from their excellent workmanship and practical manner of handling their tools, would never have been supposed to be soldiers, but from their undress uniform. Nor was the honour of the exhibition left completely with the men. Their officers competed with them at every stall, some with paintings, drawings, photography, finer pieces of workmanship, collections of curiosities, and inventions. On that occasion were exhibited experiments with signal lights by one of the officers, Captain Bolton. Captain Bolton's invention was patented, and I am glad to find that it since has been adopted by Government.

I have been a little lengthy in description, but have dwelt on these details to show the advantage that would arise from such matters, and to prove that profitable entertainments are perfectly practicable speculations.

Let us suppose, now, that an Officer of Industry is appointed to a regiment. I think it would be fair to assume that he could easily become possessed of from £20 to £50, at the very least, by some of the plans I have referred to. With that sum I can point out a dozen different branches of industry, with tools for which he can provide his men, and all of which will return quick profits.

Turning to the question of the workshops. If the authorities make a move in this matter, undoubtedly they would issue directions to the barrack masters to provide suitable places, and, although a regimental officer may be cooped up in a pigeon-hole, and his expostulations be met with an answer of "want of accommodation," yet it is tolerably certain, when the barrack people receive an order from headquarters, that, by perhaps personal inconvenience, they can find room for anything. But the Officer of Industry can be quite independent of assistance, as there are generally spare stables, and all he would require

in winter would be, to provide a couple of portable stoves, lay on the gas, and go to work. Piece-work of different kinds, of course, men could do in their own rooms.

Workshops provided, how would the Officer of Industry find his people employment? By the same channel that all establishments of the present day obtain their customers, that ready means of communication, advertising; and the men, for their own benefit, will keep a sharp look out for jobs; in fact, there can be no difficulty, as he goes into the labour market enabled to outbid all opposition on the part of those who have to feed, clothe, and lodge themselves. Nor will there be anything more easy than taking in work, as each branch of industry will have its own foreman, on the same principle as the master tailor, or the armourer sergeant, who will be answerable for all material received. With regard to employers, they will feel every security and confidence in dealing with responsible parties, whose position will be a sufficient guarantee that the work will be carefully and punctually completed. The feeling of interest for the soldier, or latent sympathy, which, though unostentatious, strongly prevails through the nation, will be brought into action, and without doubt work will be offered so abundantly, particularly as it will add to the employers' pecuniary benefit, that we need not fear any want of success on that point.

As before shown, more than one half the men are unskilled in labour, these men would therefore require to serve a kind of apprenticeship; and to a man who has been accustomed to work of some sort, there are numbers of trades that could be easily acquired in one year. During that year of learning, the unskilled soldier should be under the foreman of his branch of industry, and, of course, should recompense him for teaching the business. A fair payment for all parties would be, to allow his instructor one-third of his earnings for the first twelve months. Thus, in the course of a few years, nearly every man in a regiment would become acquainted with some handicraft, which would, *for ever* after, enable him to earn a living, either with or without connexion with the Army, or in any part of the world.

There should be one uniform system of accounts used in every battalion, as it would simplify and render intelligible all transactions. I have drawn out an industrial ledger, on a similar principle to the companies' ledger now in use, which is being printed, and will be laid on the table of the Library of this Institution for inspection. It will show, at a glance, how every man's accounts stand, and can be kept by a non-commissioned officer clerk, who should be paid out of the funds. Thus, the Officer of Industry is relieved from all personal trouble, except the superintendence and direction; the appointment would be honorary, and to any officer who cared for the service, a labour of love.

There would always be money to the credit of the Officer of Industry, accruing from two sources, first, the repayment of all moneys advanced to men for materials, or the purchase of tools, &c., which would then become their own property; and secondly, from a deduction of ten per cent. on their profits. This would meet all contingent expenses, such as the payment of the clerk, lighting, hire of machinery, and transport

of goods. By this means the system would not only support itself, independent of Government supply, but there would always be money ready to contract for work, or to purchase materials. The fund should be allowed to accumulate, nor should there ever be any division among the operatives, as the savings they could acquire at the time of the expiration of their period of service in the Army, would be to the industrious, quite satisfactory. By my plan of combining the profits of amateur amusements with the industrial profits, there would always be an increasing fund, which should remain in the regiment never to be broken, except in a case ofcharity, such as relieving the poor widow of a soldier who had died *in* the regiment. For such a noble purpose, a soldier would never grudge ten per cent. out of his earnings, as, in fact, it would only be the interest on money borrowed from his industrial bankers. Without troubling my audience with figures, I may say, that in the course of a dozen years the deposits in each regimental Officer of Industry's hands, might amount to hundreds of pounds; thus many a deserving soldier's widow could be rescued from poverty and the temptation to an evil life, which besets a destitute condition, and placed in a way of supporting herself and family, so that, in time, the fund might become one of the special charities of the Service.

The last part of the scheme I propose to establish, is the most important, viz., the appointment of an Inspecting Officer of Industry; and here it would be necessary to make a slight call on Government support. One officer would be sufficient for the duty—I am always speaking of the troops at home—he could make his tour of inspection to each regiment, aiding the Regimental Officer of Industry with his advice, examining the books, and regulating the general carrying out of details, giving lectures to the men on the subject, and organising the system in regiments on their arrival from other countries, and, of course, making his return for the information of the Commander-in-Chief. A popular man would be best suited for this position, one who could get up an entertainment, or give one, and who had a general knowledge of trades fitted for soldiers. The pay of this officer and his travelling expenses would not exceed £600 or £700 a year, so that at a cost of, say, £800 to Government—which might easily be afforded from the surplus of the Army Estimates—every soldier, during the ensuing winter, could be happily and profitably employed. Is not this a matter for serious consideration by those vested with authority?

With regard to the time soldiers could devote to industry. A mechanic's day for labour, deducting the usual allowance for meals, varies from eight to ten hours; this may be averaged at fifty hours' work for each mechanic, weekly. Now, in summer, or the drill season, if so inclined, a soldier could snatch from his spare time or intervals between his duties, eighteen to twenty hours weekly, or something equal to two mechanic's days; while in winter, when the afternoon parades could be dispensed with, a soldier might make time equal to nearly four whole mechanic's days. This would give the Commanding Officers of regiments a desirable opportunity for granting indulgences to well conducted men, as, on the recommendation of the Officer of

Industry, they could be given leave from these parades; only such names to be returned as were steady men, and found to be investing their earnings in the regimental savings bank, or otherwise properly applying them. This would be a better means of conducing to the good conduct of the Army, than the present attempt to bribe by good conduct stripes and a penny a day. It would be a considerable check to a man misconducting himself, to be suspended from entering the workshops, and to have to return to his afternoon drill.

The amount of money earned would, of course, be affected by various influences, including the class of the work, and skill of the workman; but suppose the mechanic makes 4*s.* a day, or 24*s.* per week—a very low estimate—and the soldier can make two days per week in summer, and four in winter, allowing one day per week for guard-mounting inclusive, quite as often as that duty should come; we find he could make over £30, but say £30 a year, and I believe I am not overstating it. This would in time increase to a tolerable sum.

There are persons who cavil at every innovation, and these persons might say, "This is all very well; the soldiers at first would work pretty constantly, but they would soon tire." To this I would answer, "You do not frequently find people tire of receiving or making money." The soldier is not naturally so careless and improvident as he is represented. He always has some glimmering thought of what is to become of him when his time expires. Look at the regimental savings banks, what numbers have hoarded their little sums; but if in too many cases they are reckless spendthrifts, it is because they grow impatient of adding little fractional sums—pence and pence—that almost amount to nothing in the end. But give him the opportunity of accumulating by his own exertions, and see how perseveringly he will roll along his own snow-ball. The mechanic is obliged to spend his money as he earns it; the soldier would have greatly the advantage of him, for he could view his savings daily increase with that most gratifying feeling, that he did not require to put his hand in his breeches pocket.

Having now submitted how this scheme could be established, having also explained the internal working of the plan, and the objects in view, we may proceed to an investigation of its merits; to examine the advantages or disadvantages to Government and the country, to our own military system, and to the soldier.

For the Government, it would solve the problem now found most difficult, namely, that of recruiting, and it would relieve anxiety about the wide gap in the ranks caused by the want of some eighteen to twenty thousand men. What prevents enlisting? It is not want of chivalrous feeling; but in these money-making days, young men are generally cautious. They are aware that enlistment means the investment of their capital of labour, in the lowest remunerative market. The consequence is, that the recruiting sergeant's eloquent harangue and beer are both lost, for he never can get over the fact that the recruit can earn twice the wages at any other occupation. But you grasp the vital part of the subject, when you offer to the recruit, better opportunities of acquiring money as a soldier, than as a civilian, and when

you make it clear, that instead of a man's abilities being lost, for want of use in the Army, he has greater facilities for using them. In fact, by holding out the inducements suggested, you compete in the labour market, which is in reality the gist of the whole difficulty—and outbid the civil employer by offering higher wages. Here, also, is an answer to the continual exclamations of the magazine writers, "give us a better class of men," for we should then obtain an abundant supply of such recruits as we seldom get now,—healthy, well educated young mechanics, artisans, and tradesmen.

I have considered carefully what objections Government could make to the employment of the soldier, and I can see but two: firstly, the supposition that the state would be called on for money; secondly, the fear of losing the ten years' service men; but as I have already shown, the system is self-supporting, and could not possibly involve a greater outlay than the pay of the Inspecting Officer of Industry, which would be of course a mere trifle. I deem the first objection too insignificant to require further argument. As to the loss of the ten years' service men, may I ask how many can be possibly induced to stay in the ranks now? Unfortunately very few indeed, so, that at the most, Government cannot be worse off than it is at present. But if the soldier be making money, and at the end of his ten years, finds himself in possession of one or two hundred pounds, and if you offer him inducements for his second period of service, with the opportunity of doubling, or perhaps, tripling his capital, then the mere love of money alone will probably influence him to remain. If a man devotes a portion of his life to the acquisition of money, it becomes the great object of his ambition, the passion feeds itself, the man longs to see his one hundred become two hundred, even as the millionaire keeps still in business to make his second million. Thus, the soldier will calculate upon retiring in comparative luxury and ease; the means of attaining which, no other manner of life could have given him.

With regard to recruiting, I should not wish to offer any suggestions, but as it comes in contact with my own subject, I cannot avoid making a few remarks. I would propose:—

1st. That a bounty of £5 or upwards be offered to the recruit at the time of enlistment, additional, if he agreed to serve the full time of 21 years.

2nd. That the recruiting sergeant or bringer, should get 5*s.* additional for every recruit so attested.

3rd. That it should be open to every soldier (approved of) to re-attest at any time during his first ten years' service, and that he should thereupon receive from his Adjutant the re-attesting money.

4th. That every soldier during his second period, should have but one parade each day (except in case of punishment) during the winter months, the other parades being substituted by roll calls.

5th. That all soldiers whose time was occupied with the consent of their Commanding Officer—such as in workshops—should be excused from these roll calls.

6th. That every soldier at the completion of his 21 years' service

should be entitled to a pension for the remainder of his life, equivalent to the pay he was receiving at the time of his discharge.

Were these inducements offered we might not—as many writers now do, through a large number of the ten years' service men's time expiring—contemplate wanting forty thousand men, nearly a fifth of the Army in 1870.

Colonization is another important matter for the consideration of the Government, as the soldier settling in distant lands spreads a feeling of loyalty among the inhabitants and attaches them to the mother country. There can be no such acceptable colonist, as the man accustomed to military regularity, trained to industrial pursuits, with a good knowledge of a trade, and a fair capital ready to invest, to give himself and family a stake in the country of his adoption. By this means, when the period of service expired in the colonies, the men would settle there, saving the expense of shipping home, which is no inconsiderable sum from distant places like India, whence they now frequently return to become a burden to the poor rates, or throw themselves on the generosity of their more prosperous civilian friends.

Desertion would be unknown in the ranks; if these workshops were established, a large sum would be saved annually, as no man with an opportunity of earning money, and with a goodly sum to his credit, would ever be willing to run away and leave all behind.

Now, looking at the effect on our military system, what objections could be advanced against this proposed plan of employment? It might be suggested that a sense of independence, from the possession of money, would injure the machine-like working of the ranks, making the men less subject to control. I mention however that the discipline of the Service is too perfect to be impaired in that way. Having a sum in the savings bank, can never tend to lessen a man's fighting qualities as a soldier. As a proof of this I may mention that no aspersion was ever cast on the gallantry of our officers, who, until the recent introduction of competitive examinations, were all drawn from the opulent classes of society. I think it will be conceded, therefore, that under that head there can be no objection.

To the soldier, the advantages of this proposal to establish workshops are so numerous that I shall only mention a few in which the country and the army generally are alike interested. In the first place, the health of the troops would be greatly improved, and the mortality among them very much lessened; for though the comparative statistics of civil life in different nations show the British Isles to be one of the most eminently healthy regions of the world, yet home to our soldiers is more fatal than foreign stations. The average number of men constantly sick is far greater in the United Kingdom than in any of our vast possessions, with the exception of India, China, and Ceylon, and the death-rate here, where we have camps and barracks to perfection, very much exceeds the deaths abroad. I need not say that this is a matter of vast importance, inasmuch as each soldier of the line costs about £60 by the time his training is completed. There can be no doubt that the great amount of sickness and mortality principally arises from the dissipation the men are driven to, rather than sit un-

employed in an empty barrack-room. Is it not a fact that the Corps of Royal Engineers has a smaller average of sickness in it than any of the infantry battalions, and that the men are also better conducted and more trustworthy? Does not this speak eloquently for an industrial body? The fitness of the soldier for employment is further exemplified by the public confidence placed in that excellent corps—founded by Captain Walter—the Commissionaires. As for ability and willingness to work, we must also take the Engineers as an example, for we have no other troops where trades are recognized, and we find that Government by employing one of these corps, instead of an equal number of civil workmen, saves a sum of £600 yearly.

A most important consideration is, what bearing would this question have on the marriage of the men? I do not suppose it would cause any sensible effect, nor would there be necessity for changing the already existing regulations, but those men who did marry would have a means of provision for their families which would not cease when their regiment went to distant colonies, as they could transmit their earnings, which no doubt would be greater there than here.

With regard to the wives who are now left behind, the public is, unhappily, too well acquainted with the state of destitution and its consequences into which these young women fall. Not being able to receive pecuniary assistance from their husbands, and being frequently unable to provide for themselves, who can blame them if they sink into deplorable misery, degradation, and immorality, so that on the soldier's return all ties of his former married life are obliterated? Can there be any picture more painful? The gallant and faithful soldier returning to his home, finding himself utterly bereft of the wife he loved so dearly, and of the baby he had hoped to see a man.

To the reflective mind this alone is a sufficient reason for welcoming a means that seems particularly calculated to alleviate this crying evil.

Altogether the subject is so vast, and admits of so much being said, though I have rigidly restricted myself to its proper limits, that I find great difficulty in keeping within reasonable bounds, yet I must briefly again refer to the Regimental Industrial Charity Fund.

The plan of combining the profits of amusement, and the ten per centage on the labour profits, would yield a good sum yearly, which could be banked, as it is probable that the Industrial Department would, after a time, float itself without advances, the men becoming possessed of sufficient means of their own for the purchase of material. This reserve fund, in the hands of the Officer of Industry, being exclusively devoted to regimental charitable purposes, would form, not a mere nucleus, but would develop into an important and popular institution of the Service. Look at all the sums that now go wandering about, that would be drawn within its beneficial influence. Officers who have retired, and whose memories carry them back to old associations, would remember it in their wills; officers on joining, or leaving, would make presentations; all regimental fines might be paid into it; men who had lost sight of their friends or had no relations—whose heirs we see so frequently advertised for in the papers—if they died in the regiment

would leave it their accumulated savings. The ladies of the regiment could hold annual bazaars, and collect fancy works, and men and officers, also, could send in their contributions; the soldiers' wives might be employed in making articles, and be paid for their time, so that every regiment could have its yearly fête in aid of its charity. I think I might venture to say that we should witness on all sides an honourable rivalry to increase the funds. The lectures, concerts, and amusements, that would originate for its benefit already alluded to, would afford a healthful and intellectual employment for the officers.

Before concluding, there are a few plain questions I should like to place before those who have honoured me as an audience.

Do you consider these regimental charities practicable, and should they be instituted?

Do you consider industrial employment should be established?

Do you consider that the best means of organisation is by the appointment of an Officer-Superintendent in each regiment, as suggested, on the principle of the Officer of Musketry?

To show the immense expense involved in shipping home men whose first period of service expires in distant colonies, and who refuse to renew there, though they frequently re-enlist at home, I may quote an extract from the evidence given by Lord Strathnairn, when examined before the Recruiting Commission. He states, "the great majority of men whose first period of time terminates in India, return to England; during the last year of my command 2,000 came back, and the cost of sending home these men, and sending out substitutes was so great that the Government of India had it in their consideration to give them a very large bounty, as much as £40, as a matter of economy. There is a general feeling among the men that their increased usefulness during their ten years' service is not acknowledged. I hear that this is the case from officers of a benevolent disposition, who are in the habit of mixing a good deal, and making themselves acquainted with their men. . . . I enquired from Colonel Dillon, Rifle Brigade, what means to suggest to induce these men to re-enlist; among many recommendations, he said, if they were excused from certain parades it would be a great advantage, in all of which I quite concurred." Lord Strathnairn also advocated the employment of the men at trades.

If these afternoon parades are granted to the men during the winter months, it becomes of greater necessity to devise some means of occupying their time. It may be said there are the recreation-rooms, but it is impossible to suppose that soldiers can, or will, spend all their time in these rooms. Certainly it is right to take what is given and be thankful, therefore I shall not make the slightest reflection on this movement in the Service, but I would ask others to do as I have done, enquire into the attendance at these places. In some instances men have what is termed an opportunity for working at their former trades in the recreation-rooms; but is it to be conceived that the soldier, who is in general so thoughtless, can sit down to work in the next apartment to a billiard-room or bowling-alley? And how is he to get work, and who will supply him with money for material?

If the authorities can find sums of money to expend in providing these places of amusement, why not go a little further, and provide the means of lucrative employment? The nation is increasing in wealth through her trade and industry, and why deny to the soldier the right to participate in the general welfare?

There exists no feeling of doubt that this disposal of spare time would in any way interfere with the soldierly habits, or *esprit de corps* of the Army, for very little consideration will point out that the industrial employment of the French troops never cools their military zeal, which is proverbial. I have refrained from alluding to the industrial departments of continental armies, as it already has been referred to in this Institution by Sir Harry Verney.*

There is one topic more. How would this interference with labour be received by the working classes? Undoubtedly they could not see any plausible objection, as labour is a right divine, and the market is free to all. The foreigner from every nation is welcomed to join the ranks of toil, and there are now few work-rooms in our largest towns that can be entered, without hearing some of the *employés* conversing in foreign languages. When these strangers are so generously received, how much more welcome to the English mechanic will be the soldier, the defender of the nation, and his brother countryman, to compete with him in the sturdy occupations of industry?

As the aspect of affairs throughout the world does not show any probability of our troops being engaged on active service—for we can barely look on the Abyssinian expedition as a matter of importance, with respect to fighting, when in all possibility it will never meet with an enemy—it is likely that regiments may attempt to get trades to work, but that has been frequently tried already, and did not meet with the success it should have done. The reason is, that the subject requires to be placed legitimately before the public, as an acknowledged and authorized system of the Army. It is necessary to have a proper head of the department in each regiment, with whom manufacturers could at once communicate, and in whom they would feel confidence, for assuredly employers will not part with their material until certain of its safety. It is plain by the current of public opinion, and the sentiments expressed by His Royal Highness the Commander-in-Chief, at the opening of the Guards' Institute, and also by the Secretary for War, that we may expect soon to see some initiative taken. The ensuing season may witness the soldier's highest hopes realised, and the different barracks and camps through the country filled with employed and happy men. Then may we look forward to a new era for the army—the soldier a changed being; an intelligent, thinking, trustworthy, sober, steady, well-conducted man who will no longer require any semblance of the lash; and as the State treats him well, and, above all, employs his mind, so will he give, from respect and love to the Service, what he now does from fear. Then shall we find a rich and expectant soil, in which to sow the seeds of Divine truth; then our many religious societies, all of which labour so zealously for the

* Journal, No. 32.

reformation of the soldier, will hail with pleasure a movement which so facilitates their good work; then shall we rescue the soldier from the haunts of drink and vice, training his mind to industry, and the better feelings of human nature, thereby preparing him to receive the great revelations of Christianity. But without some little assistance from Government, any attempt of this kind would be useless—and worse than useless—it would be a failure! As before stated, all movements to benefit the soldier *must emanate from within his own circle!* If this step for the improvement of the soldier's condition is ever to be taken; if these industrial employments are ever to be established; if we are ever to see shining brightly in the future, a beacon which will help to rescue the soldier's widow and his orphan, *we must first look for countenance to the highest military authorities.* Then, let this appeal be made, in the name of this good and noble charity—in the name of the so-called dissolute, idle, and forgotten soldier—in the name of the Great Giver of all charity—not to let want of consideration, or red tape, stand in the way of this most important subject!

Evening Meeting.

Monday, January 20th, 1868.

Rear-Admiral SIR FREDERICK W. E. NICOLSON, Bart., C.B., Vice-President, in the Chair.

NAMES of MEMBERS who joined the Institution between the 1st and 20th January, 1868.

LIFE.

Gordon, Wm., Lieut.-Col. Bengal Staff Corps. 9*l*.

ANNUAL.

Rawlins, John, Capt. 48th Regt. 1*l*.
Sterling, John B., Capt. Coldm. Gds. 1*l*.
Stone, Cecil P., Lieut. 77th Regt. 1*l*.
Macqueen, D. R., Lieut. 75th Regt. 1*l*.
Alexander, G. G., C.B., Major-General Royal Marine Artillery. 1*l*.
Wood, Elliott, Lieut. R.E. 1*l*.
Leycester, E. M., Capt. R.N. 1*l*.
Ommanney, F. M., Lieut. R.N. 1*l*.
Hogarth, Alexander, Major 1st Aberdeen Rifle Volunteers. 1*l*.
Pinnock, Harris N., Ens. 71st Highl. Light Infantry. 1*l*.
Whish, C. F. D., Cornet 6th Innisg. Drgs. 1*l*.
Cadell, R., Colonel R.A. 1*l*.
Browning, M. C., Capt. 87th Royal Irish Fusiliers. 1*l*.

EXPLOSIVE BULLETS AND THEIR APPLICATION TO MILITARY PURPOSES.

By Major G. V. Fosbery, V.C., H.M. Bengal Staff Corps.

In bringing before you the subject of to-night's lecture, I do so with the painful feeling that it is a very *dry* subject—indeed, one which may be instructive, but cannot be made amusing; I can only, therefore, express my pleasure and surprise that the uninviting nature of my title should not have prevented more from attending this evening.

In treating this subject, I propose to show what an explosive bullet is; give some idea of its history and construction; its effects; and in what way it may be applied to military purposes. I shall notice the objections usually made to such a use of it, leaving each to form his own opinion as to the real position of the question of its rejection or adoption as a weapon of war.

An explosive bullet stands in the same relation to a military or sporting rifle, as does a percussion shell to a field or siege gun. It is, properly speaking, a *shell* calculated to explode on striking its object, and to give, whether by the shock or the flame of such explosion, effects different from those of the solid bullet.

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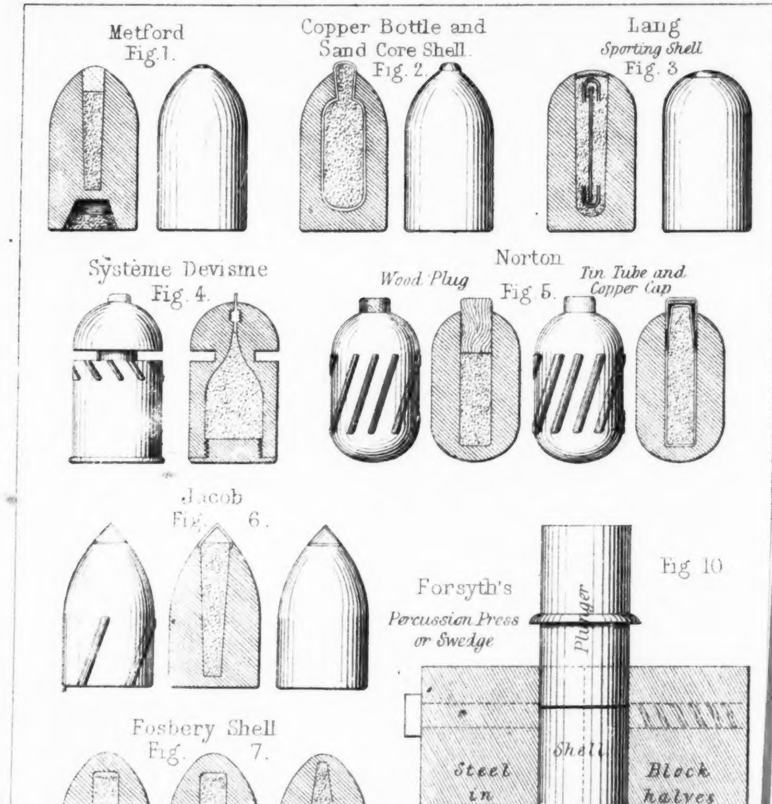
Metford
Fig. 1.
Copper Bottle and
Sand Core Shell.
Fig. 2.
Lang
Sporting Shell
Fig. 3
Système Devisme
Fig. 4.
Norton
Wood Plug
Fig. 5.
Tin Tube and
Copper Cap
Jacob
Fig. 6.
Forsyth's
Percussion Press
or Swedge
Fig. 10
Plunger
Shell
Steel
in
Block
halves
Cavity into which the Shell is rammed.
Fosbery Shell
Fig. 7.
Fosbery
Screw Press
or Swedge
Fig. 8.
Forsyth's
Black Buck Shell.
Fig. 9.

J. Jobb…

For instance, an explosive bullet or *rifle-shell* (as we may call them, if it be understood that in doing so the RIFLE is to mean a rifled small arm), will prove almost certain death even to animals too formidable to be fired at with safety with a single ball. A rifle-shell will also explode gunpowder enclosed in stout cases, such as artillery limber-boxes at extreme ranges, and when an ordinary bullet would in no ways affect it. Further, the explosion of a single Enfield rifle-shell of large capacity can be seen and heard at distances of 1,000 or 1,200 yards; whereas the ordinary bullet gives no sign. It is on these properties that its usefulness depends.

Rifle-shell are already well understood and habitually used by most sportsmen who attack the heavy game of Asia and Africa; and to their growing use it is owing that accidents from the charge of the wounded buffalo, rhinoceros, tiger, and elephant, are becoming every day less frequent and less fatal. When they were first introduced into the sporting field, there were not wanting those who denounced their use as "not giving the poor beast a chance," namely, of devouring or demolishing the sportsman, whom they considered as taking a mean advantage of his game, and being rather a poor fellow than otherwise. But in spite of such remarks, the shell has been gradually improved, and this use of it, in some form, has become at the present time almost universal.

I think indeed that no really merciful man would condemn the animal on which he draws trigger, to a lingering end from a single bullet-wound, or to the slow torture of being shot to death, as were notably some of the elephants killed by Mr. Gordon Cumming; when he may if he pleases use an instrument which will strike it down as by a flash of lightning. Even though by doing so he should deny himself the pleasurable excitement of a charge, with perhaps the demolition of some unhappy beater. In the same manner we hear the use of rifle-shell in war condemned as cruel, cowardly, or useless. If I should succeed in raising a doubt as to whether it is in truth either the one or the other, at all events a step will have been made towards the dispassionate discussion of the subject, which is all one can hope for from a paper such as the present.

I will now, if you please, enter on the history and construction of these missiles, and pass on to their uses and the consideration of the validity of the arguments used against them.

The rifle-shell was (there is, I believe, no doubt) originally proposed and made use of by Captain Norton about the year 1826, and differed but little in principle from many of those in use at the present day. I have here one of his earliest explosive bullets (Plate I, Fig. 5); it is, as you see, mechanically fitted to a polygroove-rifle, rounded both in front and rear, and having a cylindrical hollow some three-sixteenths of an inch in diameter, reaching from its apex to within a short distance of the base. In this was placed some detonating powder, and a wooden plug inserted in the head, acted as a striker on the shell reaching its object. Another form carried a small tin tube, fitted into the hollow; this was filled with gunpowder and a percussion-cap placed on the end of the tube, produced ignition in like manner at the moment of impact.

The next great inventor of rifle-shell (Fig. 6) was General John Jacob, of Jacob's Horse.

A drawing of the shell of which he is the author is before you. In such a paper as this it would be impossible to do justice to the value of the experiments carried out, under every disadvantage of climate and distance from the centres of manufacture, by that extraordinary officer. Suffice it to say, that for *ten years* he carried on, at a vast expense, and solely on his own account, experiments on a scale that, till then, had scarcely been attempted by the small arms department of any Government; and obtained years ago, results which have been but rarely surpassed, even up to the present time. After having perfected a system of rifling and construction, both of weapon and projectile, he placed the results of his labours at the disposal of his country; adding, as he did so, that the rifle-shell, if properly understood and used, would one day prove the most formidable weapon of destruction ever invented by man.

We next have the Metford shell (Fig. 1), at first sight merely a Jacob shell, having its cavity filled with percussion powder, and the orifice stopped with wax. Those, however, who should so regard it, and therefore despise in their hearts this projectile as at present introduced into the Service, would do wrong. The detonating arrangement of the shell may itself be in appearance excessively simple, but it is also wonderfully effective. Simple as it is, it cost its inventor many thousands of experiments before he was able to render it both safe to manufacture as well as to handle, and certain of explosion. It was during these experiments also, that he discovered the method of so distributing the weights of the Enfield bullet as to improve its shooting some 20 per cent.; a discovery to which much of the accuracy of shooting displayed by our converted rifles is due. His shell was also the cheapest yet made, rendered so by the ingenious machinery by which the inventor produced them; this is now-a-days no small a consideration.

A shell invented by Colonel Boxer, of which I have unfortunately no specimen, was long tried against Mr. Metford's shell. It had the advantage of carrying a flame of some duration into an enemy's ammunition waggon, and was in this way exceedingly formidable; but was also, it is said, somewhat costly to manufacture.

The question of the adoption of a shell into the Service, was in a measure settled, when, in 1862, I invented the shell which you see here represented (see Fig. 1).

I was, as you will see, indebted to Mr. Forsyth, for the idea of forming a shell in two parts, as his so-called Black-Buck shell (Fig. 9) had been already figured and described in the "Field" newspaper. But as we were in search of different objects, a very different method of setting to work was necessary in both cases. Mr. Forsyth wanted a large shell of great interior capacity, for short ranges, and cared not for the trouble and inconvenience of its manufacture, or its inaccuracy of flight, beyond a hundred yards or so.*

* The method of charging and completing the Black-Buck shell was as follows: The lower portion was filled with gunpowder, and a patch of linen or calico placed over it. The upper portion was then forced in, and the two united by hammering

I wanted a military shell also of greater capacity than could be obtained by merely hollowing the head; simple and cheap to manufacture in large quantities; and accurate up to the longest ranges.

In order to gain penetration, and have the power of increasing that penetration at will, I made the head of solid lead, and loaded the shell at the base, a thing never, I believe, before attempted. To gain a proper balance, I adopted, after many experiments, this peculiar form of hollow; and for rapidity of manufacture, a tapered tube, through which, by a screw or otherwise, the shells could be thrust one after another, and so be quickly completed.

As you will see, therefore, this shell differed in many important particulars from Mr. Forsyth's, even in the method of forming the dovetail joint, which is, indeed, their only point of resemblance—and these differences were wholly mine. It took me next a whole year of experiment before I could get it to shoot. In 1863, at Mr. Forsyth's request, I forwarded him, through a friend, a sketch of my shell and apparatus, which had then just been favourably reported on by the Indian Select Committee, and in a correspondence which ensued, clearly pointed out the points of the invention, which I claimed as original. The question, as between the two shells, was, moreover, referred to Sir Hugh Rose, who at once recognized them as distinct inventions, intended for different purposes, and claiming notice on different grounds.

Mr. Forsyth was, however, then preparing for the press a work on "the Sporting Rifle and its Projectiles;" and although I was fairly warned of what I might expect from him, I confess I was a little surprised at seeing in his published work a wood-cut taken from my sketch, and entitled, without the slightest acknowledgment, one of the "modifications of which my shell admits." He has since, I find, wholly adopted that modification, and further given himself the trouble of re-inventing my screw swedge to make it with. I merely mention these circumstances, as many of you have, I dare say, seen the shell now often called the Forsyth shell, and might recognize it in the drawing, without being aware of its history and origin. Whatever merits it may possess as a military shell have been fully recognized by the Government of India, for which I was then working. For five years I have taken no steps to dispute with Mr. Forsyth his right to what he has appropriated; nor should I do so now, did I not think it my duty, when speaking of it in this place, to vindicate such claims as I possess to the invention. These I now submit to your judgment, and through this Institution to that of my brother Officers of the Services. Mr. Forsyth is wholly welcome to whatever credit he may have obtained from others by this conduct for an invention not entirely his own. I trust, in speaking warmly of it I offend no one present; for, indeed, I think every gentleman here will admit that reputation got in this way, is purchased at a price which he would himself be unwilling to pay for it.

in his swedge. They were then taken out, the upper compartment, filled with detonating powder, and stopped with wax, or a metal plug.—G. V. F.

The shell here shown (Fig. 2) is another which has also been proposed for both military and sporting purposes, by various inventors, and it may be called a copper bottle or sand-core shell, according as the lead is poured round the one or the other. You must see, however, that, in either form, it would be tedious or expensive to make in large quantities.

Fig. 3 represents an ingenious and handy plan of Mr. Lang's, by which any hollow-headed bullet may be converted into an effective shell. He inserts in the hollow a short wire, placing a copper cap on each end, fills the hollow with gunpowder, and stops it with wax; on striking the object one at least of the caps is certain to ignite it.

Next in order, though indeed perhaps its size and importance should have entitled it to an earlier notice, comes the shell of the *Système Devisme* (Fig. 4), invented by the celebrated gun-maker of the Boulevard des Italiens, who was good enough lately to fire several of the shell before me with wonderful effect, and has kindly lent me the arm, which you see here, by which to explain to you his system. His shell, as you will perceive, is an extraordinary-looking missile, and very different from what, in our ideas, looks like work. I have, however, seen letters from Jules Gerard and other French and foreign sportsmen of undoubted character, who speak of its extraordinary performances in no measured terms; and, indeed, from what I saw myself, I should be induced to think it, for sporting ranges, by far the most destructively effective shell known, owing to its immense explosive power.

We have thus far then treated of the explosive bullet or small-arm shell as to its history and construction. Some, it will be readily seen, are well adapted for the purposes they are intended to fulfil, others are but ingenious or expensive toys; but all go to prove that such a projectile has long been considered a desirable addition to the sportsman's battery, if not to the ammunition pouch of the soldier. For my own part, I do not hesitate to avow my conviction that sooner or later, they must be very extensively used in military operations, both from their immense utility, and from the profound moral effect which their employment even in small numbers cannot fail to produce. As I believe I was the first to use these projectiles in the field, systematically, and to any large extent, and as their high utility on several occasions has been acknowledged by many distinguished officers, who from what they then saw, have been led to advocate their habitual employment, a short account of their use and effects may be interesting here. You will forgive me for any seeming egotism, but the fact is, that as the shell were employed under my sole direction, it becomes necessary to speak in the first person, and I shall make my account as mere a statement of facts as possible.

In a lecture which I had the honour of delivering lately in this theatre, I described some of the events of the Umbeyla campaign, a series of operations against the mountain tribes of our Indian northwest frontier, which took place in the great hill range, lying about sixty miles north-east of Peshawur, and between that post and the Indus.

The story of these rifle-shells will tell you how I came to be concerned in those operations, and what their special uses under such circumstances are.

In the summer of 1863, my rifle-shell had been for some time under the consideration of the Government of India, and in the month of August of that year, a Select Committee was ordered to assemble at Meerut, to experiment and report on them. Their report was favourable as to their accuracy of flight, safety in use, and general effect on some artillery tumbrils, which indeed they had blown into a great many pieces; and after the conclusion of the experiments, I went on to Simla, where the coming hill campaign was beginning to be talked of. Whilst there I was asked to assist Major Gordon, Chief Inspector of Musketry, in carrying out some experiments, with a view to ascertaining the changes in sighting the Enfield rifle which should be made when firing at extreme angles of elevation and depression. European regiments, armed of course with that weapon, were to accompany the native troops into the hills, and it was justly thought that they might be placed in many situations where such a knowledge would be invaluable. These experiments were, however, barely commenced, when the force was in readiness to start, and no results of a sufficiently accurate nature had then been obtained.

Another serious difficulty moreover now occurred to us. The English soldiers had been trained, for some years past, in judging distances entirely in the plains of India, how then, even were they most accurately posted up in every variation of angle, could they estimate the distances of their enemies in the clear air of the mountains?

I had been then for two years a regimental instructor of musketry, and was necessarily in good training as a judge of distance; yet I found myself unable to estimate any distance whatever among the hills with any approach to accuracy. Any one who has shot much both in the plains and the mountains will at once, I think, admit how totally different are the rules to go by, according as he is placed in the one or the other. Even that forlorn hope of watching for the dust thrown up by the bullet would be unavailing in the hills, as there is no dust there. A bullet striking on a rock gives no indication whatever to the firer.

It occurred to me, however, that though a bullet does not, a shell most assuredly does, give such indication, and I was thus led to propose the use of my shell as a ready means of estimating distances on service, more especially amongst mountains.

Lord Strathnairn, then Sir Hugh Rose, and Commanding-in-Chief at the time, saw in this proposition a solution of the difficulty; and within three days I was on my way to join the force with apparatus for making up the shell on the spot, with a sufficient supply of chemicals, and letters which led to my obtaining the command of a body of sharpshooters, who should test the effects of those shell on the mountains or mountaineers, as the case might be. These men, thirty-two in number, were the best shots of Her Majesty's 71st and 101st regiments, and were speedily furnished with a certain proportion of shell ammunition per man, instructed to use it chiefly to ascertain their

distances, but permitted to fire a little freely with it at first, until they should become accustomed to its use.

The first occasion on which its effects were fairly tested was the following:—

During one of the first few days after the breaking out of open hostilities, word was passed down to camp that the outposts on the extreme right were in need of reinforcements; accordingly the mountain train guns, one hundred European soldiers, a native infantry regiment, and my party of marksmen were at once ordered up in support. On our arrival at the summit of the southern ridge, which bounded the Umbeyla Pass, in a situation some 3,000 feet above the main camp, we speedily discovered why we were wanted. Colonel Keyes who was in command of the advanced posts, had accidentally discovered that an attack in force on his own position was in the act of preparation. He, without waiting for it, boldly took the initiative, went at an enemy of whose numbers he could have had but an indefinite idea, and drove them before him to the end of the ridge. Here they crossed an open plain, and took up a strong position on a high peak, known to us as the Conical Hill, and he having but his own regiment with him, and now fully aware of their numbers, sat down on the last spur of the range, and sent for reinforcements.

When we came up, the mountain train guns were lifted from the mules, and the troops drawn up in a hollow, concealed from the enemy, whose dark masses and waving standards could, however, plainly be seen from a ridge a few paces to the front. The mountain train had evidently come far enough, and must open fire from this ridge, so also must the marksmen, for the present, at all events, and now came the question of distance. One said one thing, and one another, and at last I was consulted by the officer commanding the Artillery. Three or four rifle shell gave an average distance of 650 yards for the main body of the enemy, amongst whom the little shells bursting, seemed to cause some surprise.

The fuzes are now, therefore, cut for this distance, the marksmen all carefully posted, given the range, and ordered to fire with shell, but reserve their fire until the artillery opened.

The guns, masked by sections of grey-coated gunners, hardly distinguishable at any distance from the rocks themselves, are dragged up by hand to their places on the crest of the ridge, and aim is taken between the legs of their covering parties at a dense mass of the enemy, clustered round three or four tall standards, about the very apex of the cone. A few puffs of smoke here and there curl up from amongst the pines opposite, and the matchlock balls whistle overhead, or stick with a loud whack into the stems of the trees about.

Suddenly, at word of command, the grey sections wheel right and left, and show them the bright brass howitzers ready for work. Bang goes one of them, and everybody cranes his neck to watch the shell across the valley. All right, says somebody, as a flash and round cloud of smoke come out just at the proper place, and down goes the tall standard, and a dozen of its defenders with it.

More shell follow this example, and smaller puffs of smoke now

and again show that the marksmen, too, have found out the proper place, and are doing good work.

Presently the great mass of the enemy seems to waver, and here and there a man steals away, and vanishes amongst the trees.

Seeing this, Colonel Keyes gets his men together, sounds the double, and with his gallant regiment dashes across the plain, storms the hill, captures a standard, cuts up many of the enemy, and sends the remainder flying on the road home, the artillery shelling them pleasantly as they go. And so the action is over.

So immediate a success was, it is said, mainly due to the very rapid and accurate shell fire of the artillery, and in a measure also to that of the marksmen, which shook the enemy, and prepared their minds for the success of the final charge.

In producing this accuracy by ascertaining the exact range, I think the rifle-shell may claim to have done good service, and in some measure contributed to the results of the day.

Whether this be so or not, however, I think that you will agree with me that so cheap, expeditious, and certain a way of ascertaining range in difficult situations must have practical value. It may be said that the artillery could have done just as well by means of a trial shell or two. True, they could have done so, but then a first shell well pitched always carries with it a moral effect greater than that of any of those that follow, besides which English-made artillery shells cost something considerable on the tops of Indian mountains, some 60 miles or so from your base of operations, and still further from the nearest magazines, and must not be wasted if it be possible to avoid it,—as I think I have shewn it is.

After this, these shell were used frequently, both as a means of determining distances, and also on the enemy generally, when it became desirable to produce a strong moral effect. So well did they answer the latter purpose, that they were at the pains of sending us a deputation, under a flag of truce, praying that their use might be discontinued.

They considered them unfair on two grounds, I believe; firstly, because they exploded in an objectionable way; secondly, because there was nothing they could collect of them afterwards, as they could do ordinary bullets and the balls of the spherical case, and this they thought a great hardship. The spherical case indeed were a great prize to them, when, as sometimes happened, they failed to explode; for they used to shake out the powder, and then use the case as a pot in which to melt the bullets, until one day a sad accident made them cautious.

We had discovered this propensity; and several of the Indian Shrapnel fuzes having proved failures, we used common shell instead. This they were unaware of, and tried the melting process with one of the latter, a 24-pounder. We saw them dig it out, carry it carefully to their fire, and sit round till the lead should be ready. I need not tell you with what results. But I digress.

I attribute to the use of rifle-shell by the marksmen a degree of steadiness and confidence which enabled those thirty-two men to put

hors de combat, in four hours' hard fighting, no less than 180 men, at an expenditure of $12\frac{1}{2}$ rounds per man hit—as high a result as has, I believe, ever been attained. One of the marksmen, Corporal Symester, of the 101st, picked off one of the enemy's chiefs at 750 yards; the distance of the spot where he stood having been before found by means of rifle-shell.

The services of these men were in constant requisition to indicate to their comrades, or to the artillery, the distance of any point on which fire was to be brought to bear, and were highly appreciated.

When General Chamberlain resolved on a change of position, and occupied the south side of the pass only, the opposite hill and our former posts on that side fell of course into the hands of the enemy; and we were continually annoyed by greater or less bodies of men, to whose fire from thence it became necessary to reply effectively.

I was enabled, by means of rifle-shell and a pocket compass, to make a rough and ready sketch of the position, for the use of the artillery and infantry, and accurately to lay down all the prominent points of the opposite mountain usually occupied by the enemy, with their distances from each work or *place d'armes* on our own side. When a regular plan was constructed by the engineers afterwards, I had an opportunity of comparing the two. There was a difference, but only in one distance, and that difference was only 20 yards in 950.

Such is a sketch—too long I fear—of what rifle-shell have already done. It now comes to be a point for consideration, whether such advantages as I have described, are sufficient to overcome the repugnance which, reasonably or unreasonably, undoubtedly exists to their use as weapons of war. I will endeavour to state the objections, usually made, as fairly as possible, and, giving them their full weight and importance, leave it to your judgment whether they should or should not be deemed prohibitory to us. That they will be so to other nations, or for a long period, I have much doubt.

The Prussians are said to be already arming some few regiments with the new shell-rifle of Herr Von Dreyse, which carries a shell charged with $2\frac{1}{2}$ drams of powder, and is thus a far more formidable affair than any of those yet proposed for use in England. Another Power will, I believe, adopt them for use in the mitrailleuse, or many-barrelled breech-loading cannon. If this be so, and if the effects of rifle-shell prove in the field to be at all as great as I believe they will, their general adoption will follow as a matter of course, as has that of so many other inventions in war materiel, denounced in the first instance as diabolical, or ridiculed as useless.

In the meantime, however, an important advantage has not unfrequently been gained by the first to see the utility, override the objections, and boldly use them.

In the present case the objections usually made, are the very ones I have just mentioned, viz., that rifle-shell are either Satanic, or useless—if not both.

It is a cruel method of destroying your enemy, only to be classed with the bushman's arrow or the blow-gun and Wourali poison, says

one, and takes to himself credit, and honestly enough, I doubt not, for humanity, and a kind regard for the comfort of his fellow-creatures, even when arrayed in arms against him. Yet he will take a scientific pride in the acknowledged weapons and usages of war, and use them with a good conscience to the best effect.

An enemy approaches him by sea, let us suppose; he charges that enemy's vessel with his ram and involves 800 souls in a common and instant destruction. He fires a torpedo by electricity from a wooden shanty two miles off, under his feet, with a like effect; or, finally, he pours from his cupolas into his Martin shells the molten iron which shall burn its way alike deep into the wood of the ship and the tortured bodies of the seamen; in effect, in the terrible words of the old Letters of Marque, he burns, sinks, and destroys,—the human element inclusive. On land he disembowels him with rockets, buries in his path the self-acting fougass; tears his body with the angular fragments of segment-shell; plies him with grape and canister, old iron, and broken bottles; undermines him; fills up his wells, and destroys his habitations and supplies, and makes him to die of hunger, of thirst, and exposure, or linger, it may be, for weeks, from the fearful wounds of the bayonet, the sabre, or the Snider-Enfield bullet, the latter, by the bye, almost equalling in their effects on the body any produced by rifle-shell, as may be seen by the fragments into which such a bullet divides when fired into water. All this, moreover, with the best possible intentions and most serene good faith. But let me ask you, is this really humanity? Are any of the deaths to which the greater number of the killed in war are put, strictly speaking, humane? or, if they are not, what is this humanity of which so much is made? Is it indeed a branch of that quality which leads us to clothe the naked and feed the hungry, only developed in another direction? or is it not rather a term of variable quantity, applied to homicidal cruelty, and so adjusted as to be always just one step behind the last military discovery of the day?

Have we not heard that; in the dark ages, humanity beat out men's brains with a mace, whilst cruelty used the lance, the sword, or the arrow, and that the Bishops of the period, therefore, rode into action with the mace, so as to kill without shedding of blood? A very nice distinction indeed, as you will admit. In later times were not Congreve and Shrapnel denounced as monsters for the initiation of inventions, in whose perfection we rejoice to-day? and did not even General Elliot's red-hot shot find objectors, besides the unhappy crews of the Spanish block ships? Do not think, when I speak in this way, that I am proposing a new method of death, and doing a little by special pleading for its adoption. I am merely endeavouring to place before you the light in which similar inventions of accepted value have been regarded in times past, and mooting the question as to whether the present objectors to the use of rifle-shell have or have not more right on their side.

We next come to the question of utility. As a means of ascertaining range, you have already had their claims to notice laid before you. We now come to their use against the *matériel* and *personnel* of an

army. A rather favourite objection to their use against the limbers and ammunition boxes of the artillery, is that the powder and projectiles are so stowed in the boxes that the latter protect the former and render the whole invulnerable.

To this it may be answered, that this is undoubtedly, in great measure the case on a battery first coming into action. But we must remember that every round fired by it denudes in some measure the powder of this protection, and renders a serious, if not disabling, explosion, at all events, more possible; further, large cartridges are not nice things to handle, nor are powder cases pleasant to open when the flashes from rifle-shell are every moment bursting from the wood of the carriages and boxes, or starting from the iron of the wheels and guns; under these circumstances, even supposing the *personnel* of a battery to remain untouched, the service of the guns could hardly be carried on with the same *sang froid* as usual, even by the steadiest and best trained men. The more highly trained the men, of course the more fully aware would they be of the danger.

As to reserve small arm ammunition, the Boxer cartridge fortunately gives us a complete immunity from apprehension. But this is not the case with the small arm ammunition of other powers, with the exception perhaps of the French. If, therefore, our shell are to be used as now proposed, only on ammunition boxes, the artillery must be the principal sufferers. But in aiming at the carriage, one would be very apt to strike the man, supposing him to place himself in the way. That is, if rifle-shell are to be used against artillery *matériel*, we must include the men and horses belonging to the batteries—if not in theory, at all events in practice. In practice, therefore, it will be lawful and proper to shoot an artilleryman with a rifle-shell while in the execution of his duty, but nobody else. Humanity forbids us to destroy an infantry or cavalry soldier with anything but a solid or hollow-headed bullet.

We now come, I think, to a clear idea of what this inconsistent feeling really is. It is the desire to spare the infantry and cavalry soldier not one atom of suffering, not one pang in death (for the shell kills much more instantaneously and more mercifully than the bullet), but that unpleasant feeling which attaches to any SPECIES of death which men have not been accustomed to look in the face,—that dread of the unknown—which makes a child fear to enter a dark passage without a light—which keeps country people from a haunted lane—the bravest sailor from a harbour known to contain torpedoes—or makes gallant troops shaky on ground which is supposed to be mined.

That feeling which is—say what you will—at least akin to the sentiment which more than all the bloodshed in the world has lost its battles, and which it should be the object of every improvement in war materiel to produce, whether by its known or by its supposed effects—I mean fear.

Have not the Strasbourg experiments added a new terror to the French national weapon, whose *prestige* has been augmented ten-fold by the horrid nature of the wounds it produces, wounds which, since then, the French army surgeons at Mentana have declared to be

beyond everything they had ever seen—and from their nature almost always fatal; and is there not too an undefined, and perhaps exaggerated, feeling of mingled curiosity and dread in many minds abroad as to the effect which will be produced when that mysterious *mitrailleuse* of the Emperor, whose secret is so carefully kept, once sees the light of a day of battle?

Such dread would ten-fold attend the steps of a power which should be known to possess an infantry rifle-shell, and boldly declare its intention of using it, if compelled to fight for its existence.

I firmly believe, that a greater effect would immediately accompany its first use than has done the substitution of the muzzle-loading rifle for the smooth-bore, or even that of the breech-loader for the former.

No one will face a rapid and well sustained infantry fire of shell, as all who have seen them much used, are agreed, at all events until accustomed to them; and this takes time. But if they will not face them, then life is saved rather than destroyed. In fact the old argument holds good for each fresh step in advance; the more terrible the recognised engines of destruction, the greater will be the prospect of maintaining peace; or, should war break out, the shorter of necessity will be its duration.

As this is an object for which we all, soldiers as well as civilians, should strive, I trust that the rifle-shell may receive, at all events, thoughtful consideration, as a candidate for the office of peace-maker to begin with, and as having a tendency to shorten any war once commenced, where its use is properly persevered in.

Lieut.-Colonel FLETCHER, Scots Fusilier Guards: There is one question which I should like to ask, viz., that when you used the rifle-shells, did you use them from the Enfield, and had the rifles to be specially sighted for the purpose?

Major FOSBERY: They were used from the Enfield, and the weights were so adjusted that they travelled with the same sighting as the bullet; it was by that means we were able to ascertain our distance.

Colonel FLETCHER: Could they be used with a smaller bore than the Enfield?

Major FOSBERY: Perfectly. Here is a specimen of a smaller bore than the Enfield, viz., ·451, many of which have been fired successfully.

The CHAIRMAN: If no gentleman has any further observations to make, it remains for me to propose a vote of thanks to Major Fosbery for the paper he has brought before us. I am sorry that there are not some of the members of the Council present, who have given great attention to this subject, for it is not one with which I am practically acquainted. There is one gallant officer here who could address us on the subject; but I suppose he feels himself tied by his position as Chairman of a Committee on breech-loaders. There is one omission in Major Fosbery's statement, which perhaps I may supply. In that very action which he described so graphically, in which these shells did such good execution, and were, likewise, so valuable in enabling the men to determine their distance from the enemy, Major Fosbery earned the distinction of the Victoria Cross. That I think is the only observation that I have to make. I will now in the name of the meeting return our best thanks to Major Fosbery, for the very interesting paper he has read, and also for the very clear manner in which he has placed these various inventions, as well as his own, before the meeting.

Evening Meeting.

Monday, February 3rd, 1868.

Rear-Admiral SIR FREDERICK W. C. NICOLSON, Bart., C.B., Vice-President, in the Chair.

NAMES of MEMBERS who joined the Institution between the 20th January and 3rd February, 1868.

LIFE.

Mosse, Wm., Major 26th Regt. 9*l.*

Stopford, A. B., Lieut. R.A. 9*l.*

ANNUAL.

Luard, W. G., C.B., Capt. R.N. 1*l.*

Crokat, Chas. F., Esq., Clerk, War Office. 1*l.*

Corballis, Jas. A., Lieut. 98th Regt. 1*l.*

Elphinstone, John, Lt.-Col. Staff Corps. 1*l.*

Wilson, John, Capt. 42nd Roy. Highs. 1*l.*

Morrieson, R., Col., retired f.-p. Indian Army. 1*l.*

FURTHER INFORMATION ON THE EMPLOYMENT OF MINERAL OILS AS FUEL FOR STEAM SHIPS.

By Captain J. H. Selwyn, R.N.

In my first paper on this subject, read before the Institution at the request of the Council on the 16th of January, 1865, I attempted to give a slight sketch of the origin and history of mineral oil, its chief characteristics, and probable uses. Since that time I have been assiduously working at the question, and a great variety of methods, all more or less successful, have been put in operation with the object of burning certain classes of these oils as steam generators. Some of these methods have failed of complete success from one cause, some from another, but I am justified in saying that they have been all in a measure successful, for one great truth has been incontestably established. The duty done by even the coarsest descriptions of mineral oil, as an evaporative agent, ranges from $2\frac{3}{4}$ to $3\frac{1}{4}$ times that of coal, and this result can be obtained without any special boiler being used. In saying this, I am taking 7lbs. of water only as the practical result of burning average coal, for though 10lbs. have been evaporated under exceptional circumstances, this is never obtained in actual work, and 7·5lbs. is the practical evaporation in some of the most economically conducted lines of steamers of the newest construction.

I have heard that some of the members of this Institution fail to see of what interest it is to follow this enquiry. A few words on the importance of the subject may, therefore, not be out of place.

Our annual total of coal raised for all purposes in Great Britain has now reached the enormous amount of 106,000,000 tons. It increases yearly by about 3,000,000 tons, and although we need not have much fear of the supply soon failing, it is necessary to use a wise economy

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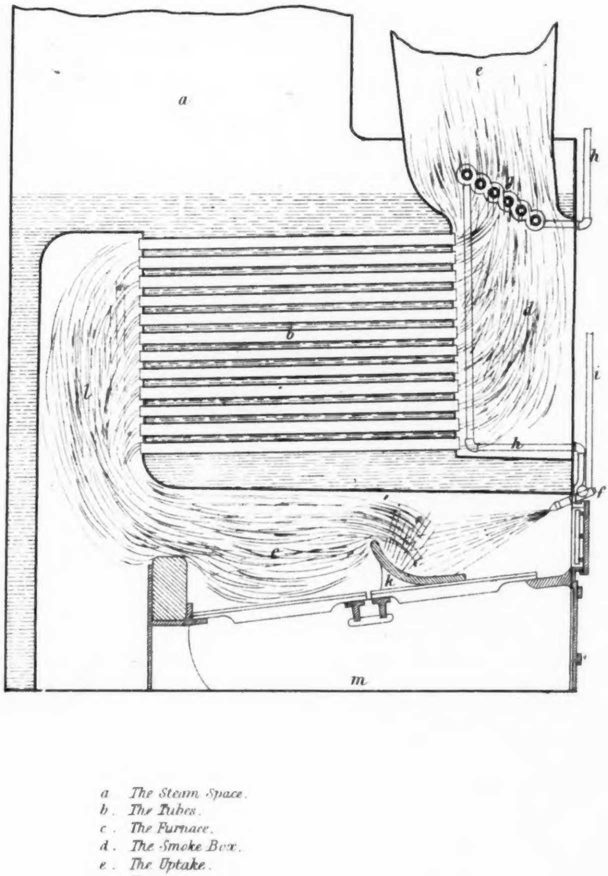
An ordinary Marine Steam-Boiler
with return Flue Tubes.

Fitted with "Wise, Field and Aydon's" patent system for burning liquid hydro carbons.



a. *The Steam Space.*
b. *The Tubes.*
c. *The Furnace.*
d. *The Smoke Box.*
e. *The Uptake.*
f. *The Injector.*
g. *The Superheater.*
h. *Pipe conveying Steam to Superheater, and Superheated Steam to the Injector.*
i. *Pipe for supplying Oil to Injector.*
k. *The Baffle.*
l. *The Combustion Chamber.*
m. *The Ashpit.*

J. Jobbi

whenever it can be practised, for fuel is one of the great, if not the very greatest, mainsprings of our wealth. He who can do with one ton of fuel that which could previously only be done (if done at all) with two, has doubled production and halved cost in such an infinite variety of ways, in such endless ramifications of industrial pursuits, that there is no one so high that he might not derive personal benefit from it, none so low that it would not materially influence the increase of necessaries or comforts he might command.

If we turn to the history of our great steam lines, we find that constant complaints have been made, that without large Government subventions nominally given for carrying the mails, they could not continue to exist, and that the expense which chiefly absorbs profits, is that incurred for fuel. If again we inspect the accounts of our Navy, we find that the expenditure of fuel in our steam ships-of-war, no matter how carefully economised, is one of the great items which makes it unfair to expect that navies should cost no more in the present than they did in the past.

There are many articles of commerce which cannot profitably be brought to market by steamers, and yet which are too perishable to bear the lengthened voyage of a sailing vessel. Extend the time during which a steamer can be driven at full speed, and your colonies are no longer so distant, the nations of the earth are brought nearer to each other. But when, in addition to the increased power of carrying fuel, the fuel itself is so changed in quality as to be more easily managed, whether in stowage or combustion, when by its use we are insured against the choking of pumps by coal dust, the loss of heat by deposits of carbon, when three stokers can do with ease what thirty were not more than competent to perform before, when, in short, so many minor advantages are to be gained, that it would tire you were I to attempt the enumeration of them, I do think that no time that is given to such a subject in such an Institution as this, can be otherwise than *time well spent.*

I regret that the boiler which has been ordered by the Admiralty for a steam launch at Woolwich is not yet quite ready for trial, in consequence solely of the time taken in adjusting the rather complicated twin screw engine which has to be fitted to it. The system which I believe to be the best and most simple, yet brought forward, and on which this first marine trial is being made, is that known as Wise, Field and Aydon's, and is represented in Plate II, and by the principal part of the apparatus itself on the table. Extended trials have, however, for some eight months past been made with it under ordinary Cornish and steam fire-engine boilers, and there is no reason to believe that the results to be obtained from marine boilers will be in any degree less satisfactory, although this particular steel-launch boiler is governed in its shape by the boat and engine to which it belongs, and is also equally well calculated for coal, if preferred.

It will, perhaps, tend to clear the ground if I commence by passing in review the objections that have successively been made to the employment of mineral oil as fuel, noting against each how far they have as yet been answered by our experience.

First then, and most important, had they been true, were the chemical theories by which it was attempted to be proved, that no greater, or only very slightly greater, evaporative value could be obtained from mineral oil, than from good coal. But here, when I sought the assistance of Professor M'Quorn Rankine, we were told in the admirable paper read before the Institution (and published in the Journal, No. 44 of last year), that this was the error of those chemists who had not studied the subject—for by the highest authorities it had been conclusively shown that nearly 23 lbs. of water ought theoretically to be evaporated by the combustion (if perfect), as it might easily be, of 1 lb. of hydrocarbon, having a constitution ranging between carbon 18, hydrogen 20—and carbon 26, hydrogen 28—or in per cent. (carbon 84, hydrogen 16), and (carbon 85, hydrogen 15). This was from laboratory experiments. I have here a pamphlet published in America, describing the results which appear to have been very carefully arrived at, of an apparatus invented by Colonel Foote, in the United States, for burning these oils in what seems to have been a 10 horse-power boiler or thereabouts. It contains testimonials from 100 engineers of all nationalities who saw the boiler in operation. The experiment has been very carefully gone through, and is scientifically tabulated throughout. It is, however, difficult to understand how the evaporation which seems to have been obtained of 23·745 lbs. of water, by one pound of petroleum was secured with carbon 12, hydrogen 12, which is said to have been the chemical constitution of the oil used.*

The experiments made hitherto in this country have given, when good apparatus was used, and all deductions made, from 19·5 lbs. to 21 lbs. of water evaporated per pound of hydrocarbon burnt; I say hydrocarbon, because we are content to use a coarser form of oil at a lower price than has been tried in America. This comes under the denomination of creosote, or dead oil of tar, and I am informed that 3,000,000 gallons of it were lately bought at three farthings per gallon, or about 13*s.* 8*d.* per ton. Here seems a good answer to the bugbear of high price, seeing that this oil is considerably cheaper than coal; I will advert however to this point again, and give you now a few evidences of what I have already asserted as to evaporative power from actual practice.

During some nine hours' trial of a ten horse-power Cornish boiler driving the machinery of a large factory; the duty done by creosote burnt in Messrs. Wise, Field and Aydon's apparatus was 19·5 lbs. per lb. of fuel. This experiment has been several times repeated.

Mr. Alfred Crow, with his apparatus, gives 1 ton of oil = 3 tons of coal.

* Carbon 12, hydrogen 12, in something like the same proportion as olefiant gas, which is carbon 4, hydrogen 4, and gives (see Professor Rankine's paper) 22·1 units of evaporation, while Captain Foote claims (see above) 23·7. But this may be due to the carbon being in a measure pure gaseous carbon when burning, when it would give a higher evaporative value than 11·25 (see Professor Rankine, page 223, No. 5 in the list of elements, and page 224, near the bottom, commencing "If we could get pure carbon in the gaseous state."—J. H. S.

Mr. Barff claims 22 lbs.

Mr. Thomas Crow of West Ham has used mineral oil in his apparatus for eight months to do the regular work of his factory. Each lb. of oil has evaporated 18·91 lbs. of water.

Another firm using this apparatus, state that the oil weighs 10·5 lbs. to the gallon. 85 gallons did the work of 1 ton 2 cwt. 3 qrs. coal, 2,548 lbs. against 892, or 2·86 more than $2\frac{3}{4}$ times the duty of that coal.

Mr. Goddard of Ipswich says, "My experience shows me that 1 ton of creosote will do the work of 3 tons of coal as fuel.

Mr. Richardson 18·5 lbs.

Mr. Crow's experiment in Mr. Richardson's boiler at Woolwich with creosote, 18·91 lbs.

In order to fix a limit, beyond which any claim of evaporative power may fairly be treated as delusive, we have only first to consider, as has been so ably shown by Professor Rankine, following the extended researches of Messrs. Fabre and Silbermann, that the more hydrogen, the more heating power or evaporative duty is theoretically contained in any substance, unless there be also oxygen present, and that the evaporative power by experiment of marsh gas carbon 2, hydrogen 4, or by weight $\frac{3}{4}$ of carbon to $\frac{1}{4}$ of hydrogen, is no more than 24·3 lbs. of water to 1 lb. of the gas. In fact with the paper of Professor Rankine, and a correct chemical analysis of the substance proposed to be burnt as fuel, there should not be the slightest difficulty to any one of ordinary capacity in estimating the evaporative results which ought to be obtained with a well-constructed boiler and apparatus.

I venture to think that I may now leave this part of the question, in the confidence that you will accept the conclusion that I have come to, viz., that both chemically and mechanically, theoretically and practically, it has been proved that, hydrocarbons have the power of evaporation here claimed for them, viz., at least $2\frac{1}{2}$ times that of coal. Above all do not let us be frightened or dissuaded from proceeding by any interested and mistaken outcry from the producers of coal, which so soon as even partial success be achieved, will not fail to be heard. They have to make the most of their coal; but we have to make the most of our navy; and I am persuaded that in this, as in all other cases, any such economic change will be eventually for the good of all classes, however much it may be combated by vested interest at the outset.

The second and next strongest objection taken to the employment of mineral oil as fuel, was the cost. This was by the objectors unwisely assumed to be the price of such oil as can be burnt in lamps. I can only repeat that of such oil as is really required, and which is now entirely a waste product, 3,000,000 gallons have been bought at three farthings per gallon, or about 13*s.* 8*d.* per ton, and that any number of millions more would be forthcoming in every part of the world, very little, if at all, enhanced in price.

If we take the Havre line of American steamers as a specimen of the results economically of burning coal, as Mr. Stimer has done in Colonel Foote's pamphlet, substituting for the $3\frac{1}{2}d.$ he makes his refuse oil cost

in America, the three farthings for which, what we want, can be got here, we arrive at very interesting results as to what might be the price of our oil before we should have to give it up as an economic success; I say economic, for the advantages in a remoter sense of enabling steam to go where it never went before, without stopping for fuel, are so boundless that I could not attempt to enumerate them within the limits of my paper.

In the Havre line there was burnt in each vessel 55 tons of coal per day, the average length of passage being 11½ days. They would then, therefore, burn on the two voyages out and home, of coal 1,265 tons, or of oil nearly 422. Each ship carries besides engineers, storekeepers and *oilers*, twelve stokers at £10 per month, and twelve coal-trimmers at £8 per month.

The food of these men costs 40 cents (1*s.* 7*d.* nearly) per day each, and they each occupy 15 cubic feet of space, which would be devoted to cargo in their absence.

Three of the firemen would be retained if oil were used.

These ships leave port with 750 tons of coal, and would have to put on board 296 tons of oil, leaving 454 tons of space for additional freight on account of coal space saved and 8 tons on account of less number of men, making 462 tons additional freight space.

The average rates in America for inward freight amount to say 24, 50 dollars currency, or £3 8*s.* sterling, and outward to Europe about 12 dollars currency, or £2 sterling. (*These figures do not represent present prices of gold or freight exactly.*)*

We then have:—

Cost of Fuel as burned.	£	*s.*	*d.*
1,265 tons of coal for both voyages at 17*s.* ..	1,025	0	0
Wages of nine extra firemen at £10 per month, two months	180	0	0
Wages of twelve coal-trimmers at £8 per month, two months	192	0	0
Food, 21 men, 60 days, at 1*s.* 7*d.* per man per diem	100	0	0
Total cost of coal	1,497	0	0
Total cost petroleum, 592 tons at 14*s.*.. ..	414	8	0
Balance in favour of petroleum..	£1,083	12	0

Now for the saving in bulk:—

	£	*s.*	*d.*
From the United States, 462 tons freight at £2 and 10 per cent. primage..	1,017	0	0
To the States, 462 tons freight at £3 8*s.* ..	1,520	0	0
	2,537	0	0
Add balance for petroleum as above ..	1,083	12	0
	£3,620	12	0

* These calculations are adapted from Mr. Stirner's clever pamphlet.—J. H. S.

Now let us see how much 592 tons of petroleum may cost and still compete with coal without taking saving in bulk into account. It may cost as much as 1,265 tons of coal at 17*s.*, *i.e.*, £1,025—or about thirty-four shillings per ton, and there will still be a saving of about £470 per round trip. But if we admit the other bulk savings shown, then it may cost about £6 per ton, and yet there will be a commercial advantage.

I shall now also leave this part of the subject, for I think it scarcely requires demonstration, that to ensure the efficiency of our ships of war for two-and-a-half times as long as we can now do without going into port, at once presents advantages which throw into the shade all the minor economies, great as they undoubtedly would be.

Another seemingly valid objection to the use of mineral oils, was the danger which might be incurred from fire, if through any want of caution, the hydrocarbons were allowed to escape into the ship, either in their original form, or as gaseous products which mixed with a certain quantity of atmospheric air (from nine to thirteen parts), would become explosive. I will at once answer this objection by remarking that coal tar has been carried and used on board ships for the last quarter of a century. It is infinitely more capable of giving off gas than such creosote as we wish to use, and even than many of the other hydrocarbon oils—and yet I have never heard in the Navy any complaint about it, save that some zealous First Lieutenants' could never get enough of it for the ship's consumption. Secondly, as this creosote happens to be heavier than water, a film of water may always be kept over it in the tanks or other receptacles, which in the improbable event of a red-hot shot piercing the armour-plated side, or in any other way getting into the tank, would prevent the access of air to the surface of the oil, and would insure its being easily covered with water to extinguish it, if after escaping on the decks through a shot-hole, it took fire.

I consider this, however, to be nearly impossible, for I have heated white pine up to 200 degrees before the fire, I have then poured the creosote upon it, and nothing but a piece of flaming charcoal would ignite it, a red hot coal having no effect, nor flame either; when by the combined heat of the glowing charcoal and flame it became ignited, it burnt freely, but without even singing the soft-wood under it. It is not subject to spontaneous combustion as some coal is. It is more easily put out when ignited, and if run into the hold where there were a few inches of water, it would be extinguished by the salt water taking the place due to a sp. gr. of 1,020 or 30—the oil being 1,050 sp. gr., unless indeed the water were from the Dead Sea, when, as that has a sp. gr. of 1,240 and the oil about 1,050, we might possibly have the oil on the top. I have also brought this substance to a boiling state, and then approached flame to it, not even then did it take fire, unless there happened to be some substance which acted as a wick, and by capillary attraction minutely dividing the particles, enabled the oxygen to combine in sufficient quantity with the carbon and hydrogen of which it is composed. I then heated it in a thin film on a sheet of

in America, the three farthings for which, what we want, can be got here, we arrive at very interesting results as to what might be the price of our oil before we should have to give it up as an economic success; I say economic, for the advantages in a remoter sense of enabling steam to go where it never went before, without stopping for fuel, are so boundless that I could not attempt to enumerate them within the limits of my paper.

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To the States, 462 tons freight at £3 8*s.* ..	1,520	0	0
	2,537	0	0
Add balance for petroleum as above ..	1,083	12	0
	£3,620	12	0

* These calculations are adapted from Mr. Stirner's clever pamphlet.—J. H. S.

Now let us see how much 592 tons of petroleum may cost and still compete with coal without taking saving in bulk into account. It may cost as much as 1,265 tons of coal at 17*s.*, *i.e.*, £1,025—or about thirty-four shillings per ton, and there will still be a saving of about £470 per round trip. But if we admit the other bulk savings shown, then it may cost about £6 per ton, and yet there will be a commercial advantage.

I shall now also leave this part of the subject, for I think it scarcely requires demonstration, that to ensure the efficiency of our ships of war for two-and-a-half times as long as we can now do without going into port, at once presents advantages which throw into the shade all the minor economies, great as they undoubtedly would be.

Another seemingly valid objection to the use of mineral oils, was the danger which might be incurred from fire, if through any want of caution, the hydrocarbons were allowed to escape into the ship, either in their original form, or as gaseous products which mixed with a certain quantity of atmospheric air (from nine to thirteen parts), would become explosive. I will at once answer this objection by remarking that coal tar has been carried and used on board ships for the last quarter of a century. It is infinitely more capable of giving off gas than such creosote as we wish to use, and even than many of the other hydrocarbon oils—and yet I have never heard in the Navy any complaint about it, save that some zealous First Lieutenants' could never get enough of it for the ship's consumption. Secondly, as this creosote happens to be heavier than water, a film of water may always be kept over it in the tanks or other receptacles, which in the improbable event of a red-hot shot piercing the armour-plated side, or in any other way getting into the tank, would prevent the access of air to the surface of the oil, and would insure its being easily covered with water to extinguish it, if after escaping on the decks through a shot-hole, it took fire.

I consider this, however, to be nearly impossible, for I have heated white pine up to 200 degrees before the fire, I have then poured the creosote upon it, and nothing but a piece of flaming charcoal would ignite it, a red hot coal having no effect, nor flame either; when by the combined heat of the glowing charcoal and flame it became ignited, it burnt freely, but without even singing the soft-wood under it. It is not subject to spontaneous combustion as some coal is. It is more easily put out when ignited, and if run into the hold where there were a few inches of water, it would be extinguished by the salt water taking the place due to a sp. gr. of 1,020 or 30—the oil being 1,050 sp. gr., unless indeed the water were from the Dead Sea, when, as that has a sp. gr. of 1,240 and the oil about 1,050, we might possibly have the oil on the top. I have also brought this substance to a boiling state, and then approached flame to it, not even then did it take fire, unless there happened to be some substance which acted as a wick, and by capillary attraction minutely dividing the particles, enabled the oxygen to combine in sufficient quantity with the carbon and hydrogen of which it is composed. I then heated it in a thin film on a sheet of

metal till it was in a state of ebullition, and then on applying some lighted paper, and dipping it into the oil, a flickering transitory flame appeared, which went out when the paper was removed. Under no possible conditions can I therefore regard it as explosive or exceptionally dangerous as fuel. Ignitable it must be, or it would not be fuel. Specific gravity is always a good guide to avoid danger in petroleum.

I have now touched upon the points of evaporative power, economy, and safety, and these I think were the chief obstacles to the general acknowledgment of the great benefits to be derived from such a new steam-generator. But if I have established that we may use it,—and our coal bills say we ought to use it,—the next thing to demonstrate is, how it is to be used. And here, as I cannot quote Professor Rankine's whole paper, I must refer those who wish to study the question to that as their text book. He has shown that it is of the first necessity that a good form of boiler be employed, that is, that the "efficiency of furnace," as he calls it, should be high, no matter what fuel is used. But no man can make an equally good furnace at one time for every kind of fuel. Therefore to make a highly efficient furnace, he must know the composition of, and the method of decomposition or burning of the fuel, he is called upon to provide for. As long as there is a smoky chimney in Great Britain (and neither they nor the other evil alluded to in a well-known proverb, have yet come to an end,) we have direct evidence for both nose and eyes, that perfect combustion of carbon in the solid form, has not hitherto been ranked among the triumphs of science. But when we find that such carbon ought to give us 15 units of evaporation, and does practically give us 7·5 just half, who will not acknowledge, that substantial progress in applying a new fuel has been made, when the total evaporative power being 27·3 (I refer to marsh gas and similar hydrocarbons), laboratory experiments give 24·3, and actual practice on a considerable scale 23·7.

If you will recollect that these are the results of experiments made in boilers not specially adapted for the oil, you will see that we need not fear to be compelled to any large expenditure on account of change in that direction. The adoption of circulating water-tubes, instead of the present smoke-tubes, would no doubt be most advisable, and would speedily pay for the expenditure, if only in diminished salting up or incrustation, an evil naturally more severely felt in marine boilers than in any others; but there is no absolute necessity for any change whatever, and with such apparatus as that on the table, the same boiler may either burn coal or oil, as preferred; and more, any boiler now in any steamship could be fitted in a month, at a very small expense, with all that would be necessary in order to enable her to burn creosote or dead earth-oil—as far at least as the furnaces were concerned. The division of the existing coal-bunkers into receptacles for the oil would not either be a very long or difficult task, and the increased profits of the first voyage would probably pay, and over-pay the whole amount expended.

But if any apparatus is to answer for a long time in the intense heat which is indicated by the high evaporative power of hydrocarbons, it

must be of the very simplest character,—even more simple (or else less exposed) than the fire-bars of an old furnace,—for they oxidized and bent, were burnt out, and were so made as to be easily and cheaply replaced; and in my selection of a system for recommendation to the Admiralty for trial, I have been mainly guided by these considerations. The apparatus of Colonel Foote exhibits more evaporative power; but not only does he use an oil which I could not expect to be accepted in this country, but he confesses himself beaten in point of simplicity and durability by Mr. Aydon. As I have no wish to engage in an inventor's quarrel, I shall refrain from any but general descriptions of the systems now in use. I understand there are no less than three gentlemen of the name of Crow, who have different systems in operation, and I have no doubt each and all who have invented and patented a "Mineral Oil-burning Furnace," think their own particular one, the "Black Swan." The main duty to be performed is, first, the thorough decomposition or mixing with oxygen in sufficient quantity, and no more than sufficient quantity. This is done in Colonel Foote's and other apparatus, by a heated retort or receptacle of whatever kind, exposed to heat in the furnace. Here the oil is, in all such apparatus, vapourised, and the difference between the varieties is, that in some, air or atmospheric oxygen, in some, both air and superheated steam, are introduced into these retorts, and there mixed with the hydrocarbon gases; in others the mixture is allowed to take place outside at the moment of combustion. I say outside the retort, for after the formation of the mixture, or, in the latter case, at the moment of formation, the gaseous compound is ignited as at gas-burners, and thus sends forth its heat into the furnace. But the system which I prefer, is one which dispenses with the retort altogether, and has nothing but fire-brick, and a superheater in any part exposed to the heat; a nozzle, or jet of superheated steam, placed over the dead plate induces round it a strong current of atmospheric air. United they impinge upon a small stream of the creosote oil, divide it mechanically into fine spray, and at the same time transform it chemically into the proper mixture of gaseous compounds with oxygen. A greater or less quantity of fire-brick is placed to receive the impinging flame, which has not a trace of smoke, and when in perfect action shows only a blue or purplish colour, this heat absorbing material fire-brick, being productive of two valuable effects, the one that of sustaining an equable heat during active combustion, the other of retaining sufficient heat to prevent the too rapid cooling of the boiler which might ensue from suddenly extinguishing the jet. A very beautiful and, I think, chemically-perfect combustion, is thus obtained.

I ought here to confess, that in 1865, though I did not myself assert, as of my own knowledge, that four to five times the evaporative duty of coal would be done by mineral oil, yet I was led to express that hope by the too confident statements of others. Further acquaintance with the subject, and months of study, have led me to a less enthusiastic but better founded conviction. Yet I can scarcely be thought wrong in having pressed so important a subject on your attention, even though it were with a little too much zeal. Though that may be a

disqualification in the diplomatic service, it has never been held to be one in my own.

Having now asked for so much of your time and attention, in saying what I thought might fairly be said in favour of this new fuel, I should think myself unfair if I did not also tell you all I know which may operate against it. There is, so far as I am aware, nothing of the kind which should prevent its being generally used. But there are special points to be guarded against beyond those obvious ones, which the objectors seem yet to have urged. When mineral oil is in active combustion, the process goes on unremittingly, and without fail, but the question of lighting it involves more difficulty. In some of the systems, superheated steam, in all a forced current of air, is necessary to prevent imperfect combustion—and a consequent deposit of unburnt carbon or soot on the heating surfaces. This is by all means to be avoided. Where superheated steam is used, this could be given from a donkey-engine, and air may be obtained from the same driving an air-pump, where it is air alone that is required. But it would be false economy to allow the tubes or other heating surfaces to be coated with a non-conducting surface at first. In a very small engine and boiler, the process should be started with coke or charcoal, or in some boilers, wood may answer. There are next two chemical peculiarities of these fuels, which depend on temperature, and to which I wish to draw your attention. I cannot give the exact temperatures, as this will depend on the constitution of the particular hydrocarbon we are using, but as to creosote, the phenomena are these:—If raised to a temperature of over 230° F., naphthaline begins to form, if any be present, and this will give trouble with the supply-pipes by choking the flow. If, on the other hand, the temperature be lowered to 32° F., a portion of the oil solidifies and does not liquefy again till a temperature of from 60° to 70° of Fahrenheit has been re-attained. Now, the objection about rise of temperature, as in the first instance, is not so important, for it is one that only requires attention to avoid; but the second is far more serious. It is true that a large portion of the oil remains liquid, even at 7° below zero, but this will not prevent the necessity for having some means of heating slightly the contents of each tank or receptacle for oil as it comes into use. Steam is the most convenient agent for this purpose, and a coil or two of pipe, being part of the fittings of each receptacle, must be turned on from a main as required. I do not think this is a thing to be frightened at, for the quantity of oil to be carried, in some cases, will be so small as to be stowed in the immediate vicinity of the boilers; in others where every nerve must be strained to carry as much fuel as possible, it will be but a slight tax on the many advantages gained in other ways, to have to provide for the oil being heated when in a frigid climate. But here again we have a chemical resource also open to us, and that is so to mix our oils as that the degree of cold that may fairly be expected, will not freeze them. I do not know what we could do for the next Arctic expedition if one ever takes place. I fear we must leave them to solid coal or pure alcohol as their best fuel.

I have ascertained to-day that 60,000,000 gallons of creosote are

produced yearly in Great Britain as the refuse result of tar-distillation alone. A still greater quantity can readily be obtained wherever the illuminating mineral oils are made.

The apparatus which I will now explain, has evaporated about 60 tons of water in actual work under a Cornish boiler. It is, as you see, about the length and size of a man's fore-arm, and has three concentric tubes, something on the same principle as Giffard's injector, one of which blows superheated steam, inducing in the others respectively atmospheric air and the oil to be burnt.

I have now only to thank you for your kind attention, and to apologize on the score of an accident by which I have been for two months confined to the house, and from which I am only just sufficiently recovered to appear here, for the incomplete way in which I have put the subject before you. It is one that will, I am persuaded, gradually increase in interest, and when further information has been attained I shall endeavour, with the permission of the Council, to make up for any shortcomings now unavoidable, and to give you a report of our trials in the steam launch now fitting for the Admiralty at Woolwich.

Admiral Sir HENRY CODRINGTON, K.C.B.: There is one question that I should like to ask. Is it necessary that it should be high pressure steam? High pressure steam is a cold operation, I have always understood. Ordinary steam gives you the full heat. But the sensation of high pressure steam—for I have put my hand into it—is a cool sensation. There is another point I should like to ask a question about. It seems to me that the quantity of fire-brick underneath the boiler bears such a small proportion to the area of the lower part of the boiler, that I can scarcely imagine that amount of fire-brick keeping it hot? With respect to the word creosote, I understand it to be the heavy refuse that is used, not the light article that we buy of chemists. Not the distilled creosote, but the coarse refuse.

Captain SELWYN: It is the coarse creosote.

Mr. C. J. RICHARDSON: You mentioned that Mr. Crow, the creosote-maker, produced an evaporation of 18·98 lb. of water to 1 lb. of creosote. He has published a statement to that effect, and has taken out a patent. Now I beg to say that that result was obtained with my apparatus, not with his. I lent him my boiler at Woolwich one entire day, for burning creosote, and it was with my apparatus that he made the experiment.

The CHAIRMAN: I believe that some gentlemen connected with this patent, of which there is a sketch on the wall, are present. We shall be happy to hear any observations they have to make.

Commander COLOMB, R.N.: I am afraid that the subject is too new to provoke much discussion at present; but I have no doubt that after we have had time to read the paper in the "Journal," we shall be able to say something to the point. As far as I understand the question, it is certainly well worth the very closest attention. If you say that we are to gain 2½ tons in stowage in our ships, or, in other words, to go 2¼ times as great a distance for a given space of stowage in our ships, I think that most important. With regard to the lighting the furnace, I do not quite see how it is managed. If I understand rightly, you must lay a fire in the first instance, or something in the nature of a fire, because you have to get your commingled spray of superheated steam and oil to start combustion.

Captain SELWYN: Not to start combustion. There is combustion at first, but with the production of some carbon, unless there be superheated steam present. As soon as the steam is raised, it becomes superheated; and then no unburnt carbon is given off. It is to obviate the objection of coating your tubes with carbon or soot.

Commander COLOMB: Then I understand that, to begin, you must employ a fan or bellows of some kind, to produce a current of air; or else you employ a second boiler,

with a small coal fire under it, to produce your superheated steam. I do not quite understand the point of starting your boiler; perhaps you will make that clear.

Mr. RICHARDSON: It is generally supposed that all these oils, shale oil, petroleum, and dead oil, vaporize; that they have only to be mixed with superheated steam to be burned as vapour. Those who say that, know nothing of the nature of these oils. They do not all vaporize. There is only a small portion, about 30 per cent., of oil, that does vaporize; and in different proportions in different oils. The American petroleum vaporizes the most; that vaporizes 40 or 50 per cent. It is absurd to suppose that you can take shale oil, or dead earth oil, and pass it through a pipe and make it vaporize. You cannot make it all vaporize. If you put it into a coke fire, all the tar will come out as tar, and put the fire out; it will go into the ash-pit, and burn like liquid fire. And if the supply of oil is not quickly shut off, that liquid fire will run out of the furnace like a stream. It is a mistake to suppose that superheated steam will make it burn. No superheated steam will make it burn; it requires to be bodily burnt.

Mr. MACKIE: There is one point which I think is worth while to bring before the meeting this evening. I know that rock oil has been burned in many ways, and that a very considerable amount of evaporation has been accomplished per pound of oil burned. I am not aware what experiments have been made or carried out, to ascertain the rate in regard to the time in which this evaporation is effected. I certainly am not adverse to the employment of mineral oil, therefore I do not speak in an antagonistic spirit at all in the matter. Everybody who has anything to do with, or has any experience of steam ships, must be very well aware that in getting up steam in great boilers, and in great abundance, for special purposes, or even for ordinary purposes, the high rate is attained by the system of firing; that is, burning coal at any amount of extravagance, so long as you raise the quantity of steam required. As far as I know, the experiments made with rock oil have been to evaporate simply so much water per pound of oil, regardless of the time it takes to do so. I should like to know whether, under Mr. Aydon's system, or any other system which has been tried so far, something equivalent to the system of rapid firing has been tried?

Mr. LEWIS OLRICK: I believe it is admitted that combustion has been very unsuccessful in nearly all steamers up to the present time. When we see a steamship, we are in the habit of seeing a long trail of smoke in the wake of that steamship. What does that mean? It means simply waste of fuel; inattention to the very first rules of how to consume coal properly. The reasons are, first, faulty construction of boiler; and next, the want of applying atmospheric air, which we can get for nothing, to combine with the gases we get from the coal, and thus to burn them properly. In many instances it is almost impossible to get a smoke consumer to act, simply for want of draught. Therefore, certain smoke consumers in which a steam jet is applied, are in most cases preferable, because we have then a mastery over the amount of air which we can inject into the furnace. Comparing coal with liquid fuel, we have got certain advantages in the liquid fuel which we have not got in the coal. In the first place, with regard to coal, there is the faulty construction of the furnace and want of attention to the proper amount of air that comes in. Next, and not least, is the chance of a bad stoker. A bad stoker can almost spoil the very best constructed boiler; at least the combustion that takes place in the best constructed boiler. Now, nothing of the kind occurs with a liquid fuel furnace. After the furnace is once started, it will go all round the earth, if it is only supplied with sufficient oil, with very little attention: and instead of having a whole army of stokers, you may have two or three, with perhaps one in reserve in case of illness; that would make four stokers, instead of twenty-four in one ship. Although I made the boiler which is now being fitted up in Woolwich Dockyard, I believe my friend behind me (Mr. Field) knows a great deal more about the combustion of liquid fuel than I do. But I have seen many cases, and I must say that at first I did not believe it was possible to produce so entire a gas flame, as I saw in the flue of an ordinary Cornish boiler of about 10-horse power. When we want to learn how to burn oil properly, we have merely to look at a parafine or petroleum lamp, and there we have a full explanation of how to do it. If the same

principle is applied in reality, as shown on that drawing on the wall, we shall get about the same amount of perfect combustion in the boiler flue as we get in our lamp. Again it will be preferable to get steam to inject not only the oil, but also the air; because we then become master of the amount of air that must necessarily go into the furnace to effect a perfect combustion. If we add to that steam a certain amount of heat, and superheat it, we know very well that highly superheated steam will decompose, and separate the hydrogen from the oxygen. Hydrogen, as far as I recollect, has 64 units of evaporation; that means that one unit of hydrogen would evaporate 64 units of water if it were possible to do so in a furnace. There is one point more. If you light up the fire with coal, as I have seen this morning in Woolwich Dockyard, you coat the whole of the heating surface with a thick layer of soot, one of the worst conductors of heat we can have; and the efficiency of the boiler sinks down from 20 to 18 and 16. The first thing you must do is to start with a clean heating surface; then you will have the full efficiency of both the oil and the heating surface. This is impossible to acquire in the ordinary coal furnace, because when you light up, you must necessarily have smoke to commence with, because at the first moment it is impossible to inject the necessary amount of air, to effect perfect combustion. This is one of the evils connected with the ordinary furnace, which will be entirely avoided with any perfect liquid fuel.

The CHAIRMAN: You alluded to some experiments at Woolwich. Were you referring to the boiler that is going to be put into the steel launch?

Mr. OLRICK: No. The boiler I am fitting into the steel launch is ready; but I am also fitting two pair of engines to the boiler itself; and on account of some small difficulties that have arisen, I have been delayed in fitting them in the manner that was first intended. The one I alluded to this evening, is in another small steamer lying there with an apparatus of Mr. Barth's. As far as I can see, Mr. Barth has simply imitated the system that you see on the table, with some slight additions that entirely destroy the proper action.

The CHAIRMAN: You say it is Mr. Barth's apparatus?

Mr. OLRICK: I was told by the officials that it was Mr. Barth's.

The CHAIRMAN: Is it a boiler for burning mineral oil?

Mr. OLRICK: Yes, but I do not know whether I saw it the whole time it was in action: but I saw it for nearly an hour smoke to that extent that it was almost dangerous to go near it.

Captain BURGESS: I should like to ask one question, viz., that were this oil used as fuel in the Royal Navy, would the present boilers require much alteration?

Captain FREMANTLE, R.N.: I wish to ask a question as to the cost of the oil. The cost is stated at 14*s.* a ton. I want to know, if the fuel was used in very great quantities, whether it would make any material difference in the price; and whether the amount that would be required would be so great that there would be any difficulty in obtaining the supply in this country, or would it be necessary to get it from America?

The CHAIRMAN: If no other gentleman has any observations to make, I will call upon Captain Selwyn to reply.

Captain SELWYN: First with regard to Admiral Codrington's questions, he must permit me to read from a much more able author than myself a better answer than I could possibly give. I asked Professor Rankine, when he read his paper here, expressly to bring out that point. Although I had some idea of it myself, yet I did not think it was quite clear. He says:—"It may be said that a certain quantity of "heat is wasted in generating this steam, but that heat is made available again. "Now, that depends, I may say, almost entirely upon the temperature at which the "steam is used. You expend a certain quantity of heat in evaporating water, and "you send the steam in at a comparatively low temperature. In the ordinary state "of saturated steam, the temperature of that, as compared with burning fuel, is "cold. It may be very hot as compared with the ordinary temperature of the "atmosphere; but as compared with the temperature of the fuel in the furnace, it "is a very low temperature indeed. A body cannot give out heat to a body that is "hotter than itself, so that the heat spent in producing steam at a comparatively "low temperature will be wasted; but if you use superheated steam, in the first

" place, a much less quantity of steam will serve the purpose. The mechanical " effect depends upon pressure and volume. In order to get a great pressure and a " great volume with small weight of material, you must employ a high temperature; " you must, in short, use superheated steam. As a great part of the expenditure of " heat in producing the steam depends on its weight, the use of superheated steam " tends to lessen the expenditure of heat for a given mechanical effect. Then, if you " raise the steam to a temperature approximating to that of the flame itself, you get " back nearly the whole of the heat again; because the superheated steam, being " at a higher temperature than the heating surface of the boiler, gives out a great " part of its heat to that surface, just as the flame does." The extraordinary fact the gallant Admiral has also remarked upon, that when you hold your hand to superheated steam it seems cold. [Admiral CODRINGTON: I meant high-pressure steam.] High-pressure steam, after a certain pressure, assumes the character more and more. Latent heat exists, or heat which does not seem to be developed in the way in which we apply our hands to it. But I think, as far as I am aware, the explanation of the question of the cold feel, is the induced current of air around you. Certain it is that there is a cold feel to the hand; that you do not scald your hand with high-pressure steam as you do with what the Americans call "stam," or with steam at lower temperature. But it is necessary for the heating power of that apparatus, and for that of any apparatus, first that the steam should be superheated to avoid the great loss of steam which will be the result of producing the same mechanical effect, with a lower temperature; and next, in order that a complete separation of gases, the hydrogen, the oxygen, the superheated steam, should be able to take place at the point without any deposition of water, and that the oxygen should be completely taken up where it is wanted.

Admiral CODRINGTON: Perhaps I may say that I held my hand very close to the jet; but I could not hold it two or three inches off.

Captain SELWYN: As soon as the pressure begins to lower, the heat is felt. With regard to the fire-brick, I was not quite understood. I did not say this was a correct representation of the furnace as it is always used. But more or less of fire-brick may be put in. If you fill the whole of this space under the boiler to the top with fire-brick, piled so loosely as to leave interstices, the whole mass will become of a glowing white heat. With regard to creosote, it is just what people choose to call it. People call things by so many names. This in my hand is called "dead oil of tar," "dead earth oil," "creosote," "acid foots," and I think half a dozen other different names by different people. The fact is, it is the refuse distillation of the illuminating oils, and the refuse of gas manufactories. Pits have been dug in the earth, and hundreds of millions of gallons buried annually in the British Islands, besides what is similarly wasted over the whole world. It could be produced in any amount required in any part of the globe, and at very little, if at all enhanced price. There is no possible fear of the exhaustion of the supply—and I am now answering two inquiries—neither is there any possible fear of a rising price beyond that which will suffice just to make it compete with coal. We must not expect that our friends who have dead oil of tar to sell will consent to sell it for nothing when they find it is worth something. The next question was Mr. Richardson's, about his boiler burning creosote. I have carefully guarded myself against the question of any one boiler being better than another, or anything of that kind. That I know nothing about, except that I have chosen a particular apparatus, which I prefer. Mr. Richardson's boiler seems to have done very good duty with creosote; but not quite so good as we have been able to obtain elsewhere. I am happy to hear that his boiler has done so well with it. While Mr. Richardson was making his observations, I took the trouble to light a little more of this creosote, which he says leaves coke. It has burned off as clear as it can possibly do; there is no coke here. We have never got coke. After six months' firing, Mr. Field will tell you, there was no residuum of coke. The creosote came into the factory in barrels, it did not come out at the bottom, the whole did burn somewhere, and as it is not apparent in the furnace or in the ash-pit, I conceive it must have vaporized and gone out of the chimney. The great thing for people who wish to burn this oil properly, will be to understand that simple alphabet on the wall; there is nothing more simple, and if

they will take the trouble to go over it two or three times, they can easily master the chemical equivalents, and the way in which they ought to burn the oil. The way to do it is certainly not to sacrifice the hydrogen; that is one thing which I totally repudiate. When I see that hydrogen gives 64 units of evaporation against 15 to be obtained from carbon in most favourable circumstances, unless it be a gaseous carbon, then I say that it would be a perfect folly to drive the hydrogen up the chimney, and think I was well rid of it. Mr. Mackie asked me if rapid firing had been tried. I do not quite understand what he means by rapid firing in this instance, because with oils the thing is to get them into active operation as soon as possible.

Mr. Mackie: I will endeavour to make clear what I wished to convey. It was this: suppose it takes a given quantity of steam to drive a steamboat at a given rate per hour, you must find steam at that rate, cost what it may. If you take the experiments which I have seen at Woolwich, and at other places; the experiments have been conducted on this system—you take a pound of oil; you burn the pound of oil out, and you calculate at 10 lb. pressure in the boiler the amount of water which has been evaporated by that pound. It may have taken six hours, ten hours, or a day, to have evaporated so much water by so much oil; whereas in steamboats you must get as much flame as you possibly can; you care nothing about the waste that goes out of the funnel, but you raise so much steam by so much fuel in a given time. Now, the point of my question was whether—given you had to get steam up at a considerable amount of pressure in your boiler—you could burn oil in the furnace rapidly enough, securing its perfect combustion, to raise the same quantity of steam in a given amount of time? You are aware that at Woolwich the coal boiler is made the test of the quantity of water a pound of coal will evaporate, and also the quantity of steam that can be evaporated in a given time. I do not know whether the oil has been tested against the coal to raise steam in a given time.

Captain Selwyn: The time given for raising steam in the most carefully tabulated experiments I have at command, was twenty minutes; but I am confident that with a good boiler, and proper means of lighting with the mineral oil—by a good boiler I understand a rapidly circulating boiler, for no other boiler is good at raising steam rapidly—with a good boiler on a proper circulating system, I have no doubt the time may be brought down to fifteen minutes at the outside.

Mr. Mackie: In raising steam?

Captain Selwyn: In raising steam to the pressure required, whether that be 60 lb. on the square inch, or only 20 lbs. It will then go on without the slightest intermission as long as you choose to supply oil to that boiler. Of course the boiler will be proportioned to give so many cubic feet of evaporation for each horse-power you require from it. That evaporation can be obtained very favourably, because, as no carbon is deposited, as in coal, it will be more constant than with coal. There was a question by Captain Colomb, about lighting up, which he said he did not understand. There are several modes of lighting. The mode of lighting constantly pursued under this boiler, because it was an ordinary Cornish boiler, which could not be supplied with any extra apparatus, Mr. Field will give you an explanation of. That is the experiment which was made by Mr. Field. I have another suggestion to make as regards lighting. It so happens that we know that a mixture of any of those oils with alcoholic mixtures renders them more vaporizable, and also banishes the smoke, and so we get perfect combustion. We may, therefore, use a mixture of alcohol to produce the effect of lighting a boiler in a short time. But I think that these will be allowed to be minor questions, when we come to consider the enormous facilities which the regular use of these oils will give. Mr. Olrick's observations on the boiler he saw, are simply what I expected from the construction of the boiler, and from the nature of the general combustion under that boiler which I have seen or heard of. There has always been at first a large quantity of smoke generated; the tubes became thickly coated with soot; they never entirely recovered their heating power, and, therefore, that boiler never did the duty which could be got from it. That is to be regretted, but I have no doubt the difficulty is to be overcome. The question is whether it was the same apparatus? You might take this apparatus as I might take this gas lamp. I can make it play all kinds of

tricks. If I give it too much air—a little too much will do the business entirely—it will spoil the whole combustion. I can clearly show that the least excess of air, from a mistake as to the quantity of air to be admitted, or the size of your tubes, or the character of your steam, will cause imperfect combustion, and will result in smoke. That does not invalidate the character of the apparatus, which, I consider, has shown its satisfactory results too often to be doubted in any way whatever. At least, I am thoroughly contented with it. I do not know that I can tell you anything further now, only to say that I shall myself hope to be prepared to speak of experiments conducted, as I believe they will be practically, by the kindness of the Controller, under my supervision. As is mentioned in Colonel Foote's pamphlet by Mr. Stimer, who seems to be a clever chief engineer in America, as has been done in that instance, so shall be done at Woolwich under my superintendence; if I am allowed to superintend, with my friend Mr. Trickett's assistance, a very accurate, close, scientific calculation shall be made, of every pound of fuel used, every second of time employed, of every iota of result obtained. That shall be at the service of every one to whom I may be permitted to give it by the Admiralty.

The CHAIRMAN: Now, Mr. Field, will you be kind enough to explain the point of lighting up under the Cornish boiler?

Captain BURGESS: There is one question that I put to Captain Selwyn.

Captain SELWYN: About the alteration in the boilers now in use in the Navy. I think I adverted to that in the paper. No alteration need be required. It is only a question of making the boiler better than hitherto. The same boilers can be used, with the same furnaces, with the same everything. They will require some closing up of the fire-doors, and the adaptation of the steam-pipe in front; and they will require, probably, the putting in either fire-brick or some material to absorb the heat, but no other alteration of any kind need be gone through.

Mr. FIELD: The furnace that Captain Selwyn alluded to, was simply lighted by taking burning coal and placing it on the grate.

Captain SELWYN: What quantity?

Mr. FIELD: A couple of shovelfuls of lighted coal placed on the ordinary grate. Then steam was turned on from another boiler, and the petroleum or creosote merely injected by the force of the steam. That produced a brilliant flame, which, after blowing for about 35 minutes, generally raised the steam to 8 lb. or 10 lb. to the square inch from cold water. As soon as the furnace became thoroughly heated, the proper combustion took place, the whole of the light disappeared, and the gas burned with a reddish-blue flame, perfectly transparent. There was not the least smoke nor deposition of carbon. There was not the slightest carbon left.

Captain COLOMB: Perhaps Captain Selwyn will say finally whether it is intended to employ a second boiler in order to supply the steam that has just been described for the lighting.

Captain SELWYN: I have given several modes by which the lighting may be done without the use of any donkey-boiler; but I would say he would be very foolish who did not use the steam from his donkey-boiler for the purpose when it is near at hand.

The CHAIRMAN: As I believe all the gentlemen who wish to make any remarks have said all they have to say, I have now to close the meeting by calling upon you to thank Captain Selwyn for his very able and elaborate paper. Before doing so, however, I should wish to make one or two observations. Since the last time that this subject was discussed here, some experiments have been made—I think in 1866—with a boiler on Mr. Richardson's plan. I will not go into the details of all those experiments, or their results; but I cannot help thinking that my friend, Captain Selwyn, takes rather a sanguine view of this subject. It is quite clear that we are on the threshold of the employment of mineral oils for fuel. I trust that he and others who have taken up the subject will persevere in their investigations. Of course, in introducing new fuel of this peculiar kind, great difficulties will have to be surmounted; and I trust that by his perseverance, and that of others, the results which he sanguinely expects, may be realized. But in his observations I think he assigned too low a duty to coal. He put it at 7 lb.

Captain SELWYN: 7·5 lb. is exactly the duty done in the best American steamers.

The CHAIRMAN: I have in my hand a Report by the Chief Engineer of the Navy. A duty of 10 lb. can be obtained.

Captain SELWYN: You never get it at sea.

Mr. OLRICK: Sometimes it is only 5 to 6 lb.

The CHAIRMAN: At Woolwich, a duty of 9½ lb. is got in the trial boiler, which should be used for the comparison.

Mr. RICHARDSON: They only produced 6¾ lb. with coal.

The CHAIRMAN: I am afraid, Mr. Richardson, your memory is fallacious.

Mr. RICHARDSON: It was 6·75 lb.

The CHAIRMAN: I should be sorry to state anything incorrectly, because I am not in the least an opponent of this fuel; I am only stating what is stated in this document.

Mr. RICHARDSON: It was 7¼ lb. the first day, 6¾ lb. the next day, with the very best Welsh anthracite coal.

The CHAIRMAN: I must be allowed to read one line: "It must be observed, how-" ever, that the evaporation in this coal boiler is low, namely, 8 lb. of water per lb. " of coal. From 9 lb. to 9¼ lb. of water per lb. of coal is, when carefully burned, " more nearly the result obtained in the marine boiler with the Welsh coal, or with " a mixture of two-thirds Welsh and one-third North country coal."

Mr. RICHARDSON: That boiler was the experimental boiler at Woolwich, the very best boiler in England. It will do more than any other.

The CHAIRMAN: It shows what a good trial-boiler it must be.

Mr. RICHARDSON: It is; but the boiler that produced 6¾ lb. was that of the "Teazer" gun-boat, which they made me use.

The CHAIRMAN: However, whatever may have been the results on that occasion, I certainly hope that this question of burning mineral oils will be prosecuted, and that in the end, it will be successful. For if we can get the same amount of steam, and reduce our expenditure of fuel 2½ times; that is to say, gain it in stowage, I am sure we shall all be delighted. I have only to add that Captain Selwyn has met with a very severe accident, and has hardly recovered from the effects of it yet; I am sure that this is an additional reason for giving him our hearty thanks for reading this paper.

LECTURE.

Friday, February 14th, 1868.

FIELD-MARSHAL SIR JOHN F. BURGOYNE, Bart., G.C.B., &c., &c., in the Chair.

CONSTRUCTION OF BOOTS AND SHOES, SUITABLE FOR THE ARMY, POLICE, POSTMEN, AND OTHERS WHO ARE SUBJECTED TO SEVERE WALKING.

By SAMUEL B. HOWLETT, Esq., late War Office.

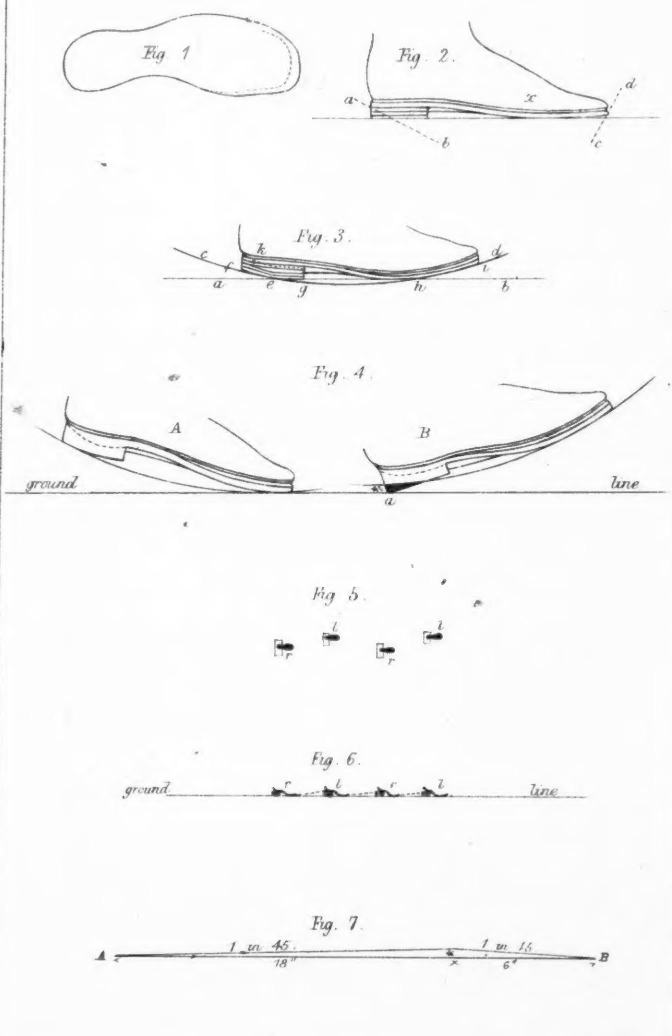
The CHAIRMAN: I regret that Major Petrie, who was to have read us a paper this afternoon on Military Administration, is unable to be present; his place will however be taken by Mr. Howlett, who will read a paper on a subject of very considerable interest to the Army.

Mr. HOWLETT: Although I have never had more to do with boots and shoes than to wear them, I nevertheless regard it as a duty to make known a few original ideas on their proper construction, thinking that my remarks may probably be of some value to persons who are subjected to severe walking, especially if they have to carry loads.

As one fact, I am going to demonstrate that a person walking in a shoe of usual construction, at every step actually goes uphill on a slope of about 1 in 45, and down again on a slope of 1 in 15, though all the time he may be walking on a level pavement; so that in a walk of say ten miles on a level road, he wastes an amount of labour equal to going up and down a hill above 800 feet high, in addition to the walk of ten miles. Certainly this is a startling fact, which seems incredible, but I will prove it, and show by what easy means the evil may be prevented, and, at the same time, that shoes may be made to last much longer. Ladies of course are also interested in this question. I have seen very elegant fashionable boots, which, in a walk of only a few miles, would cause the wearers to waste an amount of strength sufficient to take them as high as the top of the dome of St. Paul's and down again.

About thirty years ago I suffered torture in consequence of wearing shoes that did not fit. Instead of making the shoe to fit the foot, the

Construction of Boots



J. Jobbins.

shoemaker made it of the form that he considered elegant, and left the wretched foot to adjust itself to the shoe. To get rid of this torture, my feet called upon my head to do its duty; and, accordingly, I studied how a shoe should be constructed both in plan and in cross and longitudinal sections.

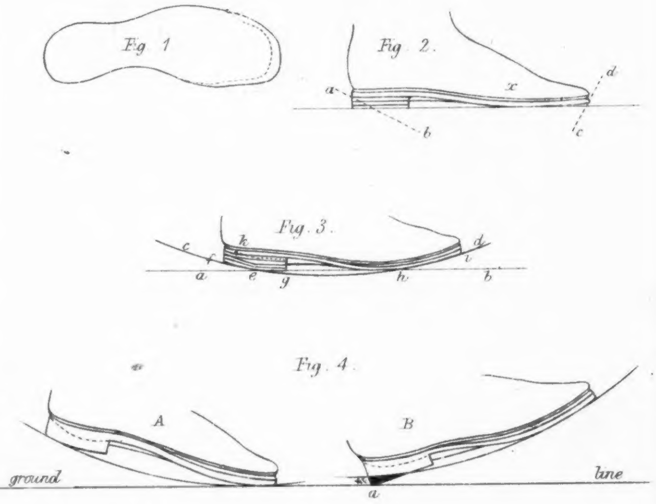
To learn how to form a shoe, I studied an old pair, so as to gain hints from nature. To obtain the plan or outline of the sole, I set my foot flat on a sheet of paper and drew a line round it. The result was the form shown in Fig. 1, Plate III, from which no deviation should be allowed except to vary the toe a little in compliance with fashion, which ordains that the toe of the shoe shall be round, square, or pointed the alteration to be external to the outline of the foot. I then obtained two common lasts, and nailed pieces of leather on to some parts, and cut the wood away in others, until one last coincided with the outline on one side of the paper, and the other last with the same outline when traced through on the back of the paper. As regards the longitudinal section, I made the toe of the last bend up to the same curve which the old shoe had acquired; and I ordered my shoemaker to make the heel of the shoe bend up behind, to the same curve as that to which the heel of the old shoe had worn itself. This outer curve I found to be parallel to the curve of the living heel, and should be at the same distance from the heel as the bottom of the sole is from the living foot. In thus copying the old shoe, I did no more than a mechanical engineer does in forming the cogs of wheels. He does not arbitrarily cast the teeth, sharp and square, but he casts them at first in the forms to which the cogs would mutually grind themselves after long wear and tear. If, too, the inside of the sole of an old shoe be observed, it will be found like a cast of the under part of the foot, in which a hollow will be noticed, caused by the pressure of the great toe; this also should be taken into consideration when making a new last.

The transverse sections, or measures of the foot, are simply taken with a strip of paper in the usual way.

Marshal Saxe declared that the success of a campaign depended more upon the legs than the arms of the soldier; and the Duke of Wellington, on being asked what was the best requisite a soldier could be provided with, replied—"a good pair of shoes." We may then assume, that suitable shoes bear a greater proportion in value, as compared even with the weapons with which a soldier is armed, than is usually considered the case. In like manner, suitable shoes are of greater importance to the public generally than would at first be supposed.

Having arrived at what I believed to be the true principles on which shoes should be constructed, and having verified those principles by my own long experience, and knowing the tortures suffered by the Army and by the public in consequence of ignorantly-made shoes, I determined to publish my ideas. Accordingly in the *Mechanics' Magazine* for July, 1856, No. 1,717, and March, 1857, No. 1,755, will be found two papers of mine on the "Construction of Boots and Shoes," the latter of which was written with special reference to the wants of

Construction of Boots



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the Army, but it applies equally to the police, and to the working classes.

Copies of these numbers of the magazine, with additional information and drawings, full size, I forwarded to the War Office. In reply, I was informed that the Inspectors of Boots considered my ideas quite contrary to all the rules for bootmaking, and that Fig. 1 was a "perfect fallacy." At any rate, this reply shows that what I proposed ten years ago, was then quite new and strange to the Army Clothing Department.

I began my first paper by saying, that while there are treatises on shoeing a horse, I had never met with any rational observations on the best method of shoeing a man. This was in 1856. In 1858, a pamphlet on shoes was published at Zurich, by Dr. Herrmann Meyer, of which an English translation was published in 1860. In 1863, an admirable pamphlet on shoes, by Dr. Günther, was published at Leipzig. Now, in both these foreign works, the diagrams showing the proper principles on which the soles of shoes should be cut, are identical with my Fig. 1; not that those learned professors of anatomy copied from me, but it is plain that their knowledge and common sense led them to the same conclusions at which I had arrived. But neither of those writers showed what the shoe should be in longitudinal section. They left their work only half done.

When the Army Clothing Department was removed from Weedon to Pimlico, and placed in charge of a new Officer, I raised the question again by sending in my paper as before. This time I received the following in reply:—"I return these papers and the two magazines, "with thanks. The principles on which Mr. Howlett proposes to "make the shape of the shoe are undoubtedly good. We are now "endeavouring to get the authorities to adopt similar principles, and "believe we shall succeed.

"(Signed) C. B. Daubeny, Col.

"Pimlico, 1 May, 1861."

Happily these principles, as regards the shape of the sole of the shoe, were adopted; and the outline of the sole of the present Army boot is identical with that proposed by me in 1856 and 1857, though at the time it was considered to be a fallacy. I think I may therefore fairly claim the credit of having been the first pioneer in this great Army question.

My suggestions as regards the longitudinal section, or side view of the shoe, as shown in Fig. 3, have, however, not yet been understood, and they still stand rejected because they are considered to be contrary to all the rules for bootmaking; this is very true, for I have never seen or heard of anything of the kind before. My method of forming the heel, as published in 1856, is perfectly original, and I am content to bear the ridicule raised against it, until I can get the credit which I believe it will be found to deserve.

As stated above, it is admitted that I was right in what I proposed in 1856 and 1857 as regards Fig. 1; and I will now attempt to demonstrate that I was equally right as regards Fig. 3, as shown more fully in the annexed plate, and that the advantages of forming the

heel in particular, like Fig. 3, instead of like Fig. 2, are of greater practical importance than would be supposed.

Fig. 2 is a side view of a boot, showing the construction that is universal, whether for clumps or for light boots. The heel is composed of horizontal courses of leather, intended to stand perfectly flat on the ground; and at the toe, the sole nearly touches the ground. The Army boot is made on the principle of Fig. 2, having the heel strongly shod with iron, and the toe a little more raised.

But, that Fig. 2 is not the natural form, is proved by the fact, that, in walking, an immediate effort is made by nature to get rid of the part of the heel below *a b*, and also to rub off the tip of the toe at *c d*, if the sole is not sufficiently flexible to bend up with the foot.

As in walking the front part of such a shoe as this requires to be bent upwards, the superfluous leather folds and creases across the foot at *x*, and is liable to crack there. Fig. 2 shows the principle upon which boots and shoes are made everywhere, I may say, by all nations, for the Secretary drew my attention to the cases in the rooms above in which there are specimens of the boots issued to the different armies of Europe, and also to that of the United States. They are all upon the principle shown in Fig. 2. They generally stand on a flat surface; the heel coincides with that surface, and the toe is more or less bent up. You will see in all the principal shops in Pall Mall, in fact in those of all the principal bootmakers, splendid workmanship as regards the stitching, and excellent leather, &c.; but you will find that this is the mode of construction. Of course everybody knows after he has walked a few weeks in a boot of this sort, that the heel immediately begins to cut away in the direction of the line *a b*, and it keeps going in that direction until it gets ragged and torn; and then it requires to be mended. Then you have it mended, and nature goes to work again; and when the heel is cut away so as to be unsightly, the boot is thrown on one side; so that from first to last you are defeating what nature attempts to do by cutting away the heel. If the boot is not sufficiently flexible, the toe is next worn off, as shown by the line *c d*. If the boot be flexible, so that when you step it bends up to take the proper curve, the leather has to fold up, and by this folding up, a crack comes, and finally you get a most unsightly split there. All this is owing to what I consider bad construction. Our wisdom in everything is to try to copy nature, to follow that fine mechanism which every work of the Creator exhibits; we should look around and see how nature works. Nature is very friendly to us if we will but follow her lead; but we won't do that, we won't take the hint about the heel, nor will we take the hint about the toe.

To obviate these and many other objections, my boot is made like Fig. 3. *a b*, is the ground line; *c d*, an arc, about 20 inches radius; *e f*, part of the heel made to coincide with the arc *c d*; *e g*, rest of heel left quite flat, and in a line with *e h; h i*, part of sole, made to coincide with the arc *c d; k*, hollow to receive heel of foot, which is on a level with the sole; thus both feet always stand and walk on the same plane, though the heel appears outside to be much thicker than the sole.

In principle, the height from the ground to the living heel should

not exceed the height from the ground to the living toe. It is not important to go to the twentieth part of an inch, but in principle we should endeavour to stand upon a level surface; though the foot is in the boot it should still be parallel to the ground. The heel here looks very thick, but then the living heel fits into a hollow in the heel of the boot, and I do not care how thick the sole and how thick the heel may be, provided you do not break that condition, and make me walk on two planes, and provided you give me those curves on which I can roll along without my really knowing upon what plane I am. In action, when the foot is thrown forward, it rolls on the curve *f-e*; it then stands flat on *e h*; and then, when leaving the ground, the foot still rolls on the curve *h i*. Hence the person always rolls along on the arc *c d*, instead of jolting along by an up and down and transverse action, as caused by the construction of the shoe shown in Fig. 2, which action I will proceed to explain.

And here I come to something very curious. I have never heard the idea stated before, and as there are mathematicians present, I shall be much obliged if they will watch and see if they can detect any flaw in my argument, any mistake in my calculations. In Fig. 4, A is the foot just leaving the ground, and B, the foot just striking the ground at *a*. The part shown in black at *a*, is, as will be noticed, added to the shoe of my construction to make the heel like the usual heel, which in this part is square, like Fig. 2; and we see that it forms, what a carpenter would call, the riser of a step, requiring the foot to be lifted up about ·4 inch above the ground plane. But if we suppose the part shown in black, at *a*, to be removed, then would the heel of my boots strike the ground at once, on the same level as the toe of A. I may say here that I have taken these proportions, the curve, and so on, from my own boot, including the four-tenths of an inch. Perhaps some other persons would wear that portion down half an inch, and others three-tenths, but I should think that, as I am a man of a middle size, four-tenths of an inch would probably be the riser of my step. It will be seen and understood with a little reflection, that by giving a curve to the heel, as shown in Fig. 3, we get rid of the riser, which occurs at the end of every step the wearer takes. But then, as my step, for instance, is only 24 inches, and the riser ·4-inch, we have a considerable slope, so much so that in ten miles the total of these risers would be 880 feet upon a slope of 1 in 45; and as much down, upon a slope of 1 in 15, as before stated, all of which is waste labour and owing to the false construction of the heel (see Fig. 7).

The following experiment, if actually tried, or only imagined, will show the exact action of a person wearing a boot like Fig. 2:—

Select some books, each nearly half an inch thick, and place them on the ground 24 inches apart, as shown in Fig. 5. Now, with your boots off, step along, putting your heels on the books, and then you will go up and down, as shown in Fig. 6, and at the same time your shoulders will rise and fall. All this causes a grinding friction, especially on the ankles, cruelly intensified when a man has to carry a load. I expect it will be said that a rise of even half an inch in a step

is not much; but then, in ten miles, this rise and fall is repeated 26,400 times.

You see it is a small step, but when you multiply that by 26,400 it comes to the very neat little figure of 880 feet. Now, to go up a hill 880 feet high when it is not necessary, is certainly not a desirable thing for a soldier. If you put a load upon a man's back—I do not know how much a soldier's accoutrements and arms weigh, but I should think it would be 50 pounds—when you put that load on a man's back the desideratum is to send him on as easily as you can without any jerks; because every jerk intensifies the blow, it doubles the weight, and it gives a friction upon every joint in his system. To take a metaphor from the spokes of a wheel; you have seen an old cart which has come to grief, with the felloe off two or three of the spokes. The wheel goes smoothly round on the sound part of the circumference, but when it comes to the bare spokes without the felloe, it jolts and rattles everything inside the cart, and tends to shake the whole fabric to pieces. That is exactly the case with a man if he walks along in a jerking, jolting way; it shakes and grinds every bone in him, and that causes weariness. Suppose the line A B, in Fig. 7, be 10 miles in length; a person wearing a boot like that in Fig. 2, going 10 miles from A to B, would go over a hill, 800 feet high; but a person wearing a boot like that in Fig. 3, would go along the level line. So that a person unwittingly, in wearing a boot like that in Fig. 2, which is the boot every sportsman and everybody else wears, would go along the hill when he thinks he is going along a level road. Instead of following nature, which guides you so kindly, you ignore her; and you won't go along the level plane, but you will go over the hill; and the consequence is there is that waste of labour. I am one of the last men who would wish to intrude myself upon others, or to animadvert upon what they do, or to interfere with departments, or with other people; but I think I am justified in stepping out of my way just to submit to your consideration whether there is truth in this statement or not. It is a matter of calculation.

In a shoe like that in Fig. 3 the least possible amount of friction is caused, because the shoe is only pressed down on the ground, not rubbed against it, and, therefore, lasts much longer. I think I may say that two pair of shoes like that in Fig. 3 will last longer than three pair like that in Fig. 2. At present the difficulty is to get shoes made like that represented in Fig. 3. Being desirous of trying experiments with iron heels, I bought a pair, and ordered them to be bent to the proper curve for my purpose; but though the workman had clear instructions, he hammered them flat. I, however, a year or two before, had got a pair of curved irons put on a pair of boots, and can now show you the different way in which the flat and the curved wear. The flat have worn in the direction of *a b*, in Fig. 2; but the curved have worn equally all over the surface, till the whole of the iron heel is reduced to the thickness of a card, without being broken through. These boots had had very hard wear indeed—the hardest wear by the sea-side and in the country. I believe they are five years old.

The usual way in which iron heels wear is this. The back part wears away, as shown at A B in Fig. 2, before the sides are worn through. After a time the heel gets worn down on the outside—it gets lopsided—all owing to bad construction. I think I have demonstrated in my boot what nature means. Nature does not object to the iron heel, provided it follows the curve of the living heel. This boot has been in hard use two or three years, and the figure of the heel is just as good as when it was first made; there is not the slightest displacement; it is as sound and as solid as ever.

To save labour and to save money are both so desirable that when once the world finds out the truth of the matter, I predict that boots and shoes made according to that in Fig. 3, as well as in Fig. 1, will gradually become universal; and in years to come, it will be hard to believe that boots and shoes were ever made on any other principles than those now submitted; they are not submitted as matters of opinion, but as matters of fact, founded on experiments, mathematical reasoning, and long experience.

From the specimens of shoes exhibited in the windows of the principal shoemakers, both in town and country, it is evident that the question of how shoes should be formed has never been studied in the kind of way which the foregoing remarks suggest. It does not appear that shoes are anywhere in this country kept on sale that are made to fit the foot, as suggested in Fig. 1; of course not according to Fig. 3, because it is new. I have, however, in some places, seen approximations to the cut of the Army boot.

But I would anticipate what strikes people as an objection. From a hasty glance they conclude that a shoe formed as suggested, would have a crooked inelegant appearance. The fact is quite the reverse. The sole is not seen, being of course under the foot, while the upper part of the shoe being an exact fit, without either unequal pressure, or any waste room, exhibits the foot in its smallest possible size, and gives it a neat, compact, and finished appearance. Under any circumstances, this mode of cutting the sole makes the best of the foot as regards its appearance; and, if adopted in early life, the foot would be preserved from those distortions which cause it pain and make it unsightly in after life.

It has been objected, that shoes intended to be kept in stock for general sale, could not be cut from actual plan of the foot as proposed; but surely it is just as easy to keep a stock of shoes of various sizes with the soles cut according to the proper type of the human foot, as to keep them ready in any other form. Nor would the form proposed cause waste of leather. To form the heel as proposed would be very easy.

I do not wish to make any observations upon what other people do, for I think it is a wise maxim, that the very best comment upon error of any kind, is just to state the truth, and leave other people to apply it. Here is the Army boot. I make no observations about it, but if I had my own way, instead of having the heel square, I should make the iron heel bend and turn up as I have pointed out. I should simply make the heel upon my principle. I trust that I shall not

give offence to any gentleman in the Clothing Department, who may chance to be present. I think what I have said is perfectly fair, and not at all offensive. This alteration can be made without any additional expense; it is simply to work it to the form I propose, and if my argument is correct, the making that little alteration, would save men the labour of going over the hill I have before mentioned. I submit to the Chief Officers in the Army whether it should not be seen to with a view to the comfort of the men.

In most trades considerable ingenuity is shown, and there is a rivalry to produce the most perfect articles. Even the tailor aspires to cut upon geometrical principles; and then having made sure of a perfect fit, he does what may be possible to give elegance to your appearance. But the master shoemaker seems to have no such ambition. Either he brings not the least ingenuity or common sense to bear upon his trade, or else he offers shoes of a form that he thinks will flatter his customers. The shoe he sells, is a fancy formation, in which the form of nature is ignored. It is very seldom that we see the true form of the foot at all recognised, and when we do, it is, I think, in shoes of foreign make. All the shoemaker does is to order certain lasts to be cut according to fancy forms which he is pleased to call "the fashion." Upon these he orders shoes to be made; and certainly the neatness and elegance of the workmanship, so far as closing and stitching go, are wonderful. But then the shoe does not fit the foot, and instead of ease you get torture. When the shoe is first forced on, it may be noticed, that while the foot points one way, the shoe points another, with part of the foot overhanging the sole. The result is, that while on one side the edges of the sole and heel are hardly worn, the edges on the other side are worn to nothing, and you finish by walking on the upper leather.

It has long been a rule with me, never to find fault with what other persons do without first being prepared to state definitely what I would do myself. In 1856 I found fault with the Army boot; and the principles I submitted for its reform having been found undoubtedly good, they were carried out, except as regards the formation of the heel. I now again show how the heel should be formed, and I show the reasons why. I now say that the whole trade of shoemaking is in certain respects wrong, and should be reformed according to the principles shown in Figs. 1 and 3.

Three years ago, I was shown a private letter from a distinguished Officer, in which he says that, "in 1820, his boots caused him much "misery, when out shooting; to remedy this, he trod with his whole "weight on a sheet of paper, traced on it the breadth and twist of his "foot, had a last made therefrom, and the result was, the difference, "in walking, between purgatory and paradise; and that he thought "that the system would be particularly valuable to the Army." But then, as it does not appear that the Officer published his ideas, as I did mine, ten years later, neither the public nor the Army have had the benefit of his experience.

Now, seeing that the form of sole shown in Fig. 1 has been adopted by the Army, has been advocated by two foreign writers, and is recom-

mended in such terms as above quoted; and seeing that the principles shown in Fig. 3 may be considered as unanswerably demonstrated, it is, I think, a pity that my boot complete is not somewhere on sale.

It appears to me that if the Civil Service Association were to have a stock of boots and shoes made upon the foregoing principles, it would promote both comfort and economy among many of the members of the Service; and that it would be of especial value to postmen, who walk ten or twenty miles a day, and are frequently laid up in consequence of being footsore, no doubt occasioned by the faulty make of their shoes. Surely twenty miles a day is a sufficiently severe task for our friend the postman, without subjecting him to a waste of labour equal to going up and down a hill a thousand feet high as before explained.

The Chairman: Gentlemen, it is impossible to deny the justice of the dictum of Marshal Saxe, that in the great operations of the field, the success of an Army depends more upon the legs than upon the arms of the soldier. If that be the case, it is of as much interest to study what will tend to the soldier's means of locomotion, as it is to attend to the rifled guns and other implements of war. Therefore I think I shall not be wrong in conveying to Mr. Howlett the thanks of this meeting for his paper and remarks upon a subject of so much interest. I have the greater pleasure in doing so, because I happen to have been associated with Mr. Howlett in the same branch of the War Office, and I can bear testimony to the ability, zeal, and energy shown in his great labours for the good of the public service, and during a very lengthened period.

Colonel Daubeney, Inspector of Army Clothing, Pimlico: I merely wish to make a remark in consequence of Mr. Howlett having by accident taken up the wrong boot, viz., the old Army boot, which has been obsolete at least, 8 years; it is not the Army boot of the present day, nor anything like it. I have placed on the table a boot taken out of a lot delivered by one of the contractors this day, showing the pattern which is now worn by the Army, and the last on which it was made, is with it. You will observe that they are pretty nearly on the same principles, so far, at least, as the toe goes, and the socket for the ball of the foot also, as Mr. Howlett's. These patterns we have had in use at Pimlico for a long time. Of course everybody has ideas upon shoes, but I may say that these alterations were made by myself, with the assistance of a very clever Officer of the Department, and were in progress—Mr. Howlett will excuse me for saying so—long before I made his acquaintance, having myself, as an Infantry Officer of thirty years' standing, repeatedly tested their merits. In fact the patterns of these boots were the result of my experiences in India, and I matured them as far back as 1848 to my own satisfaction. It is only fair to the Clothing Department to say that *this* is the Army boot of the present day, and not *that* one which Mr. Howlett showed. Here is also a zinc pattern of the sole; I think it is very much like Mr. Howlett's. The way I arrived at this, was that I got 100 men of the Guards down at Pimlico, and took a model of the *tread* of every one of their feet, and that is the result.

The boot I have now alluded to, was delivered by one of the contractors this morning, I took it out of the lot and brought it down here as a specimen of what is now actually issued to the British soldier.

Mr. HOWLETT: You will observe that the heel is quite flat; and as that is what I wanted to prove, I am glad that a boot is produced from the last supply. It appears to be an excellent boot. The sole is like Fig. 1, and if the heel were bent up like Fig. 3, then I think the boot would be perfect.

Colonel DAUBENEY: I attach no importance to a bevelled heel (proposed by Mr. Howlett) for a soldier's boot.

LECTURE.

Friday, February 28th, 1868.

VICE-ADMIRAL SIR ALEXANDER MILNE, K.C.B., Lord Commissioner of the Admiralty, in the Chair.

THE NAVAL DEPARTMENT OF THE FRENCH INTERNATIONAL EXHIBITION OF 1867.

By Commander P. H. COLOMB, R.N.

MY first introduction to the Paris Exhibition was in this wise. I had received a pressing notice from South Kensington to the effect that if intending exhibitors were not at the building to claim their space by a certain date, it would be used for the general purposes of the Exhibition. So, a day before that date I proceeded to Paris, and found myself in a large open area, partly floored, in search of an official from whom I might learn my position. In a corner of the main building I found him, and said—

"Will you kindly shew me my space?"

"Let me see," said the official, "what Class do you belong to?"

"Class 66," said I.

"Oh, poor 66," said the official, "come with me and I will shew you."

I followed him out of the building, through the mass of bricks and rubbish which then represented the park, through a subterranean passage deep in mud and filth, and finally out on to the bank of the Seine. Here we found the framework of a very large shed, partly roofed in, with a floor like a mud flat when the tide has ebbed. There was a fair sized pond in the middle of it, and some lesser ones scattered about.

My conductor walked over to one of these lesser ponds, and pointing to it with a grave countenance, said—

"This is your space."

I had come over in a great hurry and at some inconvenience to claim my space, and was not very well pleased to find a pond set apart for my especial use. I stood looking at my pond with a rueful countenance.

"It will be all right by-and-bye if the river does not rise again,—it generally rises once or twice before it finally subsides," said my conductor.

This was so satisfactory that I gave up all hopes of any result, and merely pointed to the large pond in the middle, saying—

"Whose space is that?"

"That's for Penn's engine," said the official.

My second visit to the Exhibition was some six weeks after this date.

Again I found myself in the large open area of the main building, now filled with many workmen, hundreds of cases, some closed, and some with their contents half out.

Again I sought out my friendly official, and this time my request was—

"Will you kindly tell me where I shall be likely to find my cases?"

"Let me see," considered the official, with his hand upon his chin, "what class do you belong to?"

"Class 66," said I.

"Oh, poor 66," he murmured. "Come along with me and I'll try and find your cases."

But we searched all that day and several succeeding ones, without meeting with but one case containing apparatus, and that had found its way into the haberdashery department. My space, and that of most English exhibitors, in Class 66, was still a mud flat, and the consequence was, that the cases of that class were necessitated to find successive resting places in the main building, sometimes made use of as scaffolding and platforms by practical exhibitors determined to make the best of things, but more often sworn at and viciously pushed out into the tide-way of traffic, where the "Manutention" might seize upon them and bear them to a temporary rest on the territory of some more complaisant exhibitor.

From these remarks it will be rightly judged that I do not think that "poor 66"—the naval department of the exhibition—quite occupied the position which, as the very foundation of commercial enterprise and maritime power it had some right to claim.

The class was very much scattered over the ground, and with the exception of England, no country displayed anything like an exhaustive show of its maritime progress.

I am unfortunately unable to speak from personal observation of the complete French display, as their naval department was unfinished when I left Paris in the middle of May, and I think that omitting France and England, the show was meagre.

The French display inside the building was, as far as it went, very good.

There was one large case containing very admirable models of existing iron-clads, the "Magenta," "Gloire," and those with which we became familiar in 1865, when their fleet visited our shores.

England, as it was her place to do, exhibited a wonderfully complete and well-arranged epitome of her progress and position in the naval world. "The Admiralty shed," as it was called, formed, even to the

landsman's eye, one of the most complete and attractive departments in the whole exhibition.

The Russian section was not so well represented as might have been supposed from her great enterprise and increasing maritime strength, but there appear to have been indications of the tendency to be in the van in the race of progress, which seems to be a very marked characteristic of that great power at the present day. Thus, while the main part of the displays of England and France were historical records of past triumphs, Russia gave us a few ships, embodying the most advanced opinions in respect of naval warfare.

Austria, Prussia, and America were very slightly represented, Italy would also have been in the same category, were it not that she made a very creditable and rather remarkable display of ironwork for shipping.

In one particular, France and England were represented, as probably no nations had ever essayed to exhibit themselves before. I refer to lighthouses, and the means of lighting and marking coast lines. Nothing could exceed the beauty, variety, and perfection of the apparatus displayed by both countries in a department of maritime science second to none in importance.

In the matter of ship-building, vessels of war naturally hold the first place in an exhibition; and just now when the whole question of their build, material, defensive and offensive armament, is familiar to the general public, and hotly debated in the professional circles of all nations, we may expect great varieties of model, and many lines of argument visibly carried out. Accordingly, from the huge two and three decker, through the iron-clad broadside frigate, turret ship, monitor, and ram: down to the sinkable torpedo vessel; we have a chain of illustrations, more or less complete, of the vast field now ranged over by the modern idea of a ship of war.

The great achievement—I think the greatest achievement I have ever seen in model illustration, was found in the English Department, in the beautiful ideal navy of the future displayed by Admiral Halsted and Mr. Napier. This group of model ships of war united a completeness of detail marvellous to see, and a care and finish of workmanship not exceeded in any part of the Exhibition. Admiral Halsted will, I hope, place in our journal some enduring record of his work, to describe which would require at least a separate paper.

The battle of "the turret versus the broadside," was illustrated in the English Department by a variety of models, some of ideal ships, but most of them by models of ships either actually afloat, or building. Russia exhibited models of the broadside iron-clad, the large class turret ship, and the "Monitor." Austria hinted her ideas of what is to come, by exhibiting a model of the now celebrated "Ferdinand Max," but showed nothing of her notions of a turret ship. America, from whom we might have expected the newest and most startling developments of modern ideas, was totally unrepresented. France showed us nothing in the way of turret ships, from which we could draw any conclusions as to her views.

As regards the question itself, the illustrations in the Paris Exhibition

neither advanced it, nor drew it back from the position it has for so many years held, namely, one of great uncertainty and wide difference of opinion. Nor do I expect that this generation will see a definite settlement, unless some nation will undertake to acknowledge and face the utterly antagonistic ideas prevailing, and will consent thereupon to very humbly begin from the beginning: so that, by a series of inductive experiments, the questions of dispositions of weight, freeboard, rolling, and speed, shall be established upon true principles, and not left matters of speculative argument, about which the widest—I was almost saying the wildest—opinions are freely bandied about, and what is worst, acted on.

But what nation will incur the expense, or where are the men to be found who will commence and bring to an issue within reasonable time, a series of experiments so delicate and costly? Not England, we may be pretty sure, for if there be one thing that England hates more than another, it is a definite view; and it strikes no body of Englishmen as anything but natural and proper that after the turret system has been some ten years before us, we should have its great advocate claiming that less tonnage is required for a turret than a broadside-ship; and, on the other hand, Mr. Merrifield announcing publicly that one of the chief defects of the turret system is the enormous displacement it requires.

This, the starting point of the whole question, is in the position indicated by those two expressions of views, and I saw nothing in the Paris Exhibition which led me to hope that any nation was making systematic attempts to ascertain, before committing themselves, whether Captain Coles or Mr. Merrifield was right.

Then again there is that much-vexed question of low and high freeboard, which received its best illustration, on one side, in the Russian Monitor "Latnick," and, on the other side, in the models of the "Monarch," "Marengo," and our broadside frigates. But when one passed from model to model with the idea of arriving at some definite conclusions on the great naval topic of the day, one felt that so far from assisting in that process, the general display was bewildering and hopeless. Those who believed in high freeboard showed models in which it was provided; and those who took the other side—and they were in a decided minority—simply showed models in which their idea was developed. But what advantage was all this to any inquirer who wanted to see how things were likely to go? We knew before that opinions differed on all points of the question, and hardly wanted the Paris Exhibition to assure us of the fact. To my own mind, nothing in the Exhibition conveyed less satisfactory ideas than the helpless and unsystematic way in which all nations were attacking the question. There are certain things required to be separately experimented on, and separately ascertained, before we can satisfactorily spend a penny, and yet every nation is going on spending immense sums on new classes of ships, without any attempt to find out beforehand whether the expenditure will be successful.

I notice, for instance, that Captain Coles is quite sure that a "low freeboard" and a steady platform were convertible terms. Admiral

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Elliot, in this Institution, laid all rolling at the door of disposition of weights—the engines and boilers. Others as distinctly lay down the law that the form of the bottom is the thing to be looked after. Others assert most positively that high freeboard is a preventive of rolling, as it raises the position of the centre of gravity.

Then comes one of those complicated propositions out of which mortal man never yet found a way. Thus: high freeboard is necessary for a broadside ship to keep the guns out of the water. This necessitates large plated surfaces, which, again, mean large displacements, large tonnage, and powerful engines. Then comes the other side, which says you cannot work your guns on the broadside because you must have high freeboard, and high freeboard will make you roll; therefore, you must work them in turrets. Next comes a third party to the argument, who says, "If low freeboard is good for the turret-"ships, it must be equally good for the broadside. What will happen "if you get rid of this mass of weight which is not water borne, and "make a broadside-ship which has a low freeboard?"

Lastly, there comes a weary enquirer, similar to myself, seeking for something like a fact on which to hang his opinions, who says, "would it not be well before we proceed to argue the point, to get some data on which to argue?"

Would it be very impossible, for instance, to construct two sections of vessels exactly alike, on a small scale, to vary the weights, height of free-board, and all points now in dispute, and ascertain what their *real* relations are to sea-worthy qualities?

How can the question ever be settled so long as we trust to experiment with ships on full scale, the sea-going qualities of which involve as their basis, at least, three factors whose values are unknown, namely, height of free-board, disposition of weight, and form of body.

There was in the whole Exhibition only one sign of any such attempt, this was the instrument of Admiral Paris, for measuring the rolling. The instrument consisted of a strip of paper, travelling at an uniform speed above and lightly resting on, a marker which traced the rolling and pitching in curves on the surface. The marker was the axis of a revolving disc, which being set in rapid motion, maintained its parallelism in the well-known principle of the gyroscope, and consequently gave a perfectly accurate tracing of the actual motion of the vessel on the travelling paper.

But this was an attempt at the attainment of definite ideas, which, as I before remarked, as Englishmen, we are bound to repudiate with the scorn such attempts deserve.

As regards the actual construction of ships, the series of drawings exhibited by the Committee of Lloyd's, illustrative of the "composite" system of ship-building, was well worth examination. This has been correctly described as a system where iron is used for the ships, and wood merely as a planking to keep out the water. And one could not help feeling on examining these drawings that there was a great deal of sound sense in the principle enunciated; iron, for the tensile strength so much required in ships of present enormous tonnage, and wood to resist abrasions and distribute pressure.

As regards armour-plating, I think a noticeable feature in the systems of England and France might be observed in the comparative smallness of French plates, and the much greater number of bolts employed in each plate. It was difficult to say from a general survey of the models, whether the tendency was towards complete or partial plating. I incline to the belief myself that partial plating, which was generally characteristic of the models, is an accident of the time, and that as knowledge of the subject is further developed, means will be found for giving complete plating; it may be of less thickness than at present, but of improved resisting power. I could, however, trace no sign of this in the Exhibition.

The English Government displayed very beautiful models of the structure of some of the newest iron-clads, internal fittings, and ventilation; this was wanting in the display of all other nations, but were it not so, it would be impossible, in the limit of time allowed for this paper, to do more than glance at the subject. The advance made by us in structure is the adoption of the double bottom. A ship like the "Warrior," if she once touched the ground would become a wreck almost to a certainty, for she has but a single thickness of iron on the bilge, to bear the weight of her enormous mass. While in the "Bellerophon," rocks may pass through her outer bottom while leaving the inner skin, or the actual ship, intact. But in my opinion, no war ship is perfect which has not her bottom sheathed with 6-inch plank. The first of our iron-clads which gets on shore, will hardly, unless the bottom be soft, come off again; and it appears to me that we run a most extraordinary risk in trusting ships of such costliness to the chances of a soft bottom.

We seem to have gone to the extreme in the matter of the length and tonnage of ships, and the tendency appears to be to bring back the length and tonnage to more moderate limits. I say this, notwithstanding the appearance of models, such as Admiral Halsted's ideal first-rate of 10,000 tons, of the "Minotaur" and "Northumberland," and of the Spanish "Numancia" of 7,000 tons burthen. But the newest patterns of ships show a desire to put a limit on length and tonnage. Seeing that in the relations of beam to length, the models show us an advance of from 1 to 4 in the "Duke of Wellington," to 1 to nearly 8 in the "Minotaur," it will be apparent that the extreme lengths cannot progress in like ratio for the future.

Fine entrances, and fine runs, are the noticeable features of all the newer ships. The abolition of the cutwater, and substitution of the upright, or tumbling-home stem, seems all but finally decided on, although the amount of tumbling home is by no means settled. There is evidently a double idea at work about the bows of modern ships: first the lightening forward, which is obtained by withdrawing the weight of an overhanging superstructure from its usual place; and next, a more or less decided contemplation of the use of the ram as a weapon. I only saw the model of one ship in which a full dependence was placed on this weapon; this was in the French department, and, if I rightly remember, was a model of the "Taureau." She is a ship of 2,400 tons, 196 feet long, and 47 feet beam, and is not armed for broad-

side fighting at all. She has a turret well forward, mounting, I think, two guns, which fire in line with the keel, and the whole of her bow is plated in, so as to resist any shot fired end-on to her. Her stem is fitted entirely for ramming, and she must needs give any one who believes in that mode of fighting, a very strong notion of her power.

Generally speaking, round, or pointed sterns are superseding the old square or elliptic ones; and the quarters are made purposely heavy, in order to protect the rudder and screw.

The general result of these changes is towards what a nautical eye, educated to believe in the beauty of graceful curves, must be characterised as the extreme of ugliness; but no doubt we shall learn to see and set up a new standard of beauty to meet the change of circumstance. For the idea of beauty in a ship is as the idea of beauty in a woman; and both break through and idealise the fantastic dress in which fashion or necessity clothes them. As a rule the eye rebels against a violent change in either the form of a ship, or of a woman's dress, but as it only takes a season to educate us up to the proper stage of admiration for the latter, I see no reason to doubt the same result will take place with the former.

Of course, in regard to the armaments of ships, the Paris Exhibition did not offer any illustration of a tendency other than an increase in the size of guns and a diminution of their number. As I have before remarked, and cannot too often repeat, I believe we are not laying sufficiently to heart this extraordinary reduction in the number of guns carried by ships; or, to put it better, in the number of shots capable of being fired by ships in any given time.

To come down from 121 guns in the "Victoria," in 1859, to six guns in the "Captain," of 1867—the latter being rather the larger vessel of the two, and to see the models of these two vessels opposite one another as specimens of naval architecture at the present day, is enough to show us that we are only on the borders of the question of attack and defence of ships, and that it is most improbable matters will either remain as they are, or continue to develop in their present direction.

As regards means of propulsion, the display at the Exhibition showed the gradual disappearance of the paddle as a propeller, either for the ordinary commercial requirements, or for war vessels of any size. But, on the other hand, we see that for passenger traffic, and for all classes of vessels where great speed, small carrying power, and light draught of water are the requirements, the paddle-wheel shows some signs of re-juvenescence. Greater boiler-pressure, and consequent increased number of revolutions, has reduced the size of engines and the diameter of paddle-wheels, so that in the models of yachts, mail steamers, and despatch vessels, the old huge towering paddle-box has disappeared, and a low, graceful curve in midships alone denotes the presence of the paddle. For grace of form, these newer paddle steamers are not put to the blush by any older specimens.

The single screw, two or four-bladed, is the mode of propulsion adopted in nine-tenths of the models exhibited. The English generally adopt for war purposes the two-bladed screw, means being given

for raising it out of the water when under sail. In the latest patterns, however, this idea of raising the screw—long ago abandoned by the French—seems disappearing. The enormous weight of the screws of first-class iron-clads has no doubt hastened this conclusion, but the interference offered by the screw-well with the steering arrangements, has had more to say to it. The conviction has also been gaining ground, that steaming power, and handiness under steam, should alone be attended to in the larger class of war vessels, and consequently trifling impediments to handiness or speed under sail have been more and more neglected. The French generally prefer the Mangin-screw, four-bladed, but with the second pair of blades behind the first, and in the same line, instead of being set at right angles to the diameter of the first pair, and in the same plane with them. The English use almost exclusively the Griffith-screw, or modifications thereof.

The twin-screw is clearly gaining in favour with all nations, although it was not shown at the Exhibition as adopted to vessels of large size. But there were a great many of the smaller class of vessels exhibited —as the "Smertch," in the Russian department, and several in the English department—using the twin-screw. The advantages of the twin-screw for war vessels ought to be more distinctly understood than they are. Its advocates almost invariably set its manœuvring power, as first and most important on the list. I have no doubt whatever that this power must come last; for, as I have before remarked in this place, in the open sea, quickness in manœuvring is the most essential feature, while smallness of space occupied, is the chief desideratum in harbours and among fixed points. The minimum of space combined with the minimum of time, constitute true manœuvring power, and if a twin-screw ship, with proper rudder area, puts into action her peculiar power of backing one screw, while going ahead with the other, she does it at a sacrifice of time, although at a gain in space.

The true advantages of the twin-screw must be looked for in different directions. It gives efficient propulsion at light draught of water. It will enable the naval architect to shorten his ships, while increasing the beam, and it removes the chances of fatal damage to the propulsive power, twice as far as it was under the system of single screws.

It is as yet premature to say whether or no water propulsion, as illustrated in the model of the "Waterwitch," exhibited by the Admiralty, will run a race with twin screws. So far as I understand the theory, Ruthven's propeller should beat any kind of screw working in free water, for it should economise power in the matter of lateral slip. In every screw when revolving in free water, resistance is not entirely in a line with the keel, but is radial from the boss, so that the resistance at the extremities of the blades would, if resolved into its constituents, shew a considerable power exerted at right angles to the line of keel, and, therefore, useless for propulsive purposes. It is probably to this circumstance that we must attribute the otherwise remarkable fact of the almost imperceptible decrease of speed due to cutting off the corners of the old pattern screw. Now in the hydraulic propeller, as everything

is enclosed, and the water is not freed until it has performed its office, it would seem we should get economy of power. It is a subject of regret to me, as it is so often now in respect of other matters, that the hydraulic propeller was not treated somewhat more inductively, or that at any rate attempts were not made to sift the principle to the bottom on a small scale, where the expense of alterations would have been slight, before embarking in a trial so considerable as that involved in the fitting of the "Waterwitch," where, whether she succeeds or fails, the causes thereof may be so numerous as to defy selection. This is, however, another of those cases in which our constitutional objection to tentative experiment operates with injurious effect. We have so little faith in experiment, yet I believe the failure of our experiments may not be unjustly traced to this want of faith at the beginning. Speaking personally, I have immense faith in small experiments. In the minor subjects which have engaged my attention, it has been a matter of necessity for me to jump to no conclusion, but to lead up to it by very gentle steps; I cannot say, on comparing notes with others who have pursued a somewhat different course, that I have ever found this method either a slow or an expensive one.

Arguing from small things to great, I feel strongly impressed with the belief that small tentative experiments carried out entirely with a view to the establishment of principle, would, if more largely employed by the Government, be productive of most economical results.

As it is with the "Waterwitch," it is quite open to discussion whether, and to what extent, the principle is economical, but supposing that Government comes to a conclusion adverse to it, it will still be open to its advocates to assert that the question has not had a fair trial, and that the form of the ships, disposition of weights, &c., are the real defects, and not the propeller. But supposing it be decided that the propeller is an economical one as compared with those now in vogue, then its other advantages will be manifest. It has all the manœuvreing powers of the twin screw, with a less demand for draught of water, and it has also the extraordinary and incalculable merit of being under the personal control of the officer in charge of the deck. The power being the same through all pitching and sending of the vessel, should give an advantage over the screw or paddle, whose power varies much in a heavy sea, while the immediate application of the full power of the engines in opposite directions should give a safety in action and in navigation, hardly to be exaggerated.

The "Waterwitch" was the only specimen of water propulsion exhibited.

Of minor, though not less novel modes of propelling vessels exhibited, one by a French inventor, and the other by Colonel Evelyn, in the English department, deserve notice. The principle is the same in both, but if success should ever attend its application in practice, probably Colonel Evelyn's plan would be found most perfect. The principle is that of the bird's wing. Great exposure of surface on one motion being given, and a withdrawal of that exposure when a reverse motion is communicated. In the French plan, a blade hinged

at its upper edge, so as to hang vertically, is attached to the end of a shaft, which is a continuation of the piston-rod, in a line with the keel. Instead, however, of being directly continuous, there is an arrangement on the principle of the lazy tongs, by which the length of stroke of the piston is multiplied considerably. The action of the machine is such that the out-stroke of the piston pushes the surface of the blade against the water and so propels the ship, while the back stroke allows the lower blade to come in edgeways. The back stroke is consequently lost, but, on the other hand, the power required for it is small.

In Colonel Evelyn's plan the hinged blade works vertically up and down a rod fixed abaft the stern-post. In the downward stroke the blade is at an angle of 45°, the outer edge being upwards, and in the up stroke it is again at 45°, but the inner edge is upwards. Thus nearly the whole of each stroke is utilized for propulsion. There is no rudder, but, instead of it, the propeller itself is turned from quarter to quarter by an ordinary steering-wheel, so that the whole power of the engines may be exerted at any angle with the line of keel. It is, to say the least of it, a singularly ingenious application of a known principle.

The objection to both these methods of propulsion is supposed to lie in the jar given to the whole structure by the blow of the blade against the water at each stroke, and thence communicated to the stop, or buttress, against which it rests. I am not quite prepared to say that this is a just idea; the float of a paddle-wheel is an analogous apparatus, and the Nasmyth hammer stands a probably heavier jar. And on the other hand, there is an evident simplicity and diminution of friction in transmitting the power direct from the piston without converting its travel into circular motion previously.

The enormous length in ships as displayed in the Exhibition, and their great speed, brought out as a correlative growth, great variety of steering apparatus. England displayed 15 varieties, France and Italy 3, Denmark and Sweden 1 each.

The varieties of rudders proper, were all in the English department, and were four in number—the ordinary rudder, the balanced rudder, Lumley's, and Hewitt's. On the ordinary rudder, I need make few remarks. Its demerits have always been twofold—first, the enormous increase of power required with every increase of helm angle, and as a consequence, the great strain brought upon the rudder head at such times. The first default has brought out a variety of appliances for acquiring this power, while the danger of the rudder head being wrung, has been met by the substitution of iron for wood, and by other methods of strengthening, which I need not particularise. The danger of wringing the rudder head was increased in our days by the introduction of rudders pivotted on the axis of the head, in lieu of those where the pintles were placed before it. It was a neater and more complete arrangement, but it required the application of something stronger than wood to make it perfect.

The balanced rudder is decidedly the greatest innovation of modern times in steering apparatuses, and yet, like most things which we are accustomed to call innovations, it is but a revival after all. The prin-

ciple of the balanced rudder was patented by Earl Stanhope before the close of last century, and lay in abeyance until taken up by Mr. Scott Russell for some of his ships. Its failure there, for reasons unknown to me, led most people to suppose that the principle was false, and so matters remained till 1861, when Admiral—then Captain, Key—to whose logical mind and unbiassed judgment much recent progress in marine *materiel* is due,—rightly concluded that the theory of the balanced rudder was true, and capable of application to practice. Acting on this conviction, he obtained leave from the Admiralty to carry out a complete series of experiments with a gun-boat, in order to establish or destroy the truth of his views. The experiments resulted in a complete triumph for the rudder, leading to its adoption in several of Her Majesty's ships, as well as in many foreign ones, and opening the door, I have no fear in asserting, for its ultimate adoption by all classes of ships.

Very great misconceptions with regard to the value of the balanced rudder, and the objects attained by it, exist; these, it cannot be otherwise than beneficial to remove. The balance rudder then, *per se*, has no more and no less power to turn a ship than any other rudder of the same length and breadth. It only proposes to abolish the two defects mentioned above, as belonging to the ordinary rudder. It so arranges the pressure of the water on its surface, that instead of being all abaft the axis on which it turns, enough shall be before it to compensate for that which is abaft. When this is secured, there is neither a wringing strain upon the rudder head, nor resistance against the tiller when hard over. We have heard from time to time remarks upon the admirable steering qualities of the "Bellerophon,"—a model of whose balanced rudder and fittings was exhibited,—under steam, coupled with defects attributed to her rudder, in her steering powers under sail. Unless it can be shown absolutely, that this defective steerage does not exist in the ship herself, it is unreasonable to attribute it to the rudder; for while there are *prima facie* reasons why the rudder should act well under steam, there are none why it should not act equally well under sail. In a properly balanced rudder, the helm may be put over to any angle, and righted again without expending more force than is necessary to overcome the friction in its bearings. This alone is quite sufficient to secure its place as the greatest improvement in the steering of ships brought to our notice in the Paris Exhibition. The rudder, however, is not without its defects. In order to allow for the arc described by the foreside of the rudder, its axis must be some distance from the stern-post, rendering it perhaps difficult to use ordinary pintles and gudgeons.

In the model of the "Bellerophon's" rudder exhibited by the Admiralty, it is only held by two bearings—one a collar round the rudder head, and the other a collar formed by a prolongation of the keel. The spindle of the rudder passes through it, and is secured on the under side by a nut. Many competent judges consider two bearings only, one at the waterline, and the other at the keel, an insufficient security both against a heavy sea, and also against taking the ground. In Admiral Halsted's ships the rudder has a further support of a

central pintle and gudgeon, and Mr. Scott Tucker exhibited a method of remedying this defect, which appears simple enough. He cuts out portions of the foreside of the rudder, sufficiently deep to allow it to pass freely above and below two gudgeons, prolonged from the sternpost to the pintles in a line with the axis of the rudder. Below these pintles the rudder is still more cut away, so as to allow the gudgeons to pass under these while shipping it. To effect this, the rudder must be placed at right angles to the keel, when the pintles fall into their places. When the rudder is in the position for use, the slots are not wide enough to allow of its unshipping.

Lumley's rudder comes next for consideration. The inventor exhibited five models, fitted on his first, second, and third systems; and the Admiralty exhibited one specimen of the first system, as fitted to Her Majesty's ship "Columbine," and very favourably viewed in reports from that ship. The principle of the Lumley rudder is, that a small portion of the afterpart shall, when the helm is put over, be always at a greater angle with the line of keel than the forepart. Whether the inventor has any special theory to show that a rudder of this form exerts, *per se*, greater turning powers than an ordinary one, I do not know; but if we avoid the complicated and unstable problems of hydro-dynamics, and take the force exerted by the water as a statical pressure, we shall find that an ordinary rudder of smaller area, at a slightly increased angle, will do more work. This may be easily understood by reflecting that when an ordinary rudder is at 45°, it is then exerting its maximum turning power. If you take a Lumley rudder of the same area, and place the forepart of it at 45°, that part is then doing as much turning work as the same portion of the ordinary rudder did; but the afterpart, being necessarily at a greater angle than 45°, is doing less turning work than the same portion of the ordinary rudder. Consequently the whole rudder is less effective. Did time permit, this might be shown to be true for every angle at which the rudder can be placed. If, however, it be disputed that the laws of ordinary statical pressure apply, it seems still by no means clear that the modifications which arise from considering water as the source of pressure, make against the theory. It seems probable that the angle between the two faces of the rudder would practically be filled up by dead water, and therefore any value it might possess would be lost, the water in motion passing off this dead water as it would off any solid surface. I am not about to deny the value of the Lumley rudder in a certain direction to be presently noted; but I think it of the utmost importance that the direction in which its value lies, should be clearly indicated. The experiments on which I found my view of the balanced rudder were conducted on the principle of rigid competition with an ordinary rudder, under exactly similar circumstances in the same vessel. It is the only way of trying the comparative merits of rudders, and I know of no such experiments with Mr. Lumley's.

The real advantage of this rudder appears to me that a portion of the strain is taken off the rudder head, and placed upon what may be called a false rudder head, the fixed pivot which by its eccentricity gives motion to the after rudder-piece. The probability is that helm enough

to produce a given result may be used by the helmsman with a less expenditure of force with the Lumley rudder than with the common one. This of itself would be quite sufficient to produce favourable reports where no comparisons could be made, but it seems probable that side by side with the balanced rudder which reduces the required force to a minimum in a simpler way, the Lumley rudder will not have a very extended reign.

In both these appliances it is sought by modifications of the rudder itself to overcome the difficulties of the question, but a much commoner plan, of which great varieties were displayed, is to leave the rudder untouched, and to apply mechanisms to the tiller, or yoke, in assistance of manual power. It is rather singular, by the way, that there was not a single specimen of any steering apparatus which proposed any other than manual labour as the prime mover.

Perhaps the most wonderful of all these appliances is the one to which we are most accustomed, namely, the ordinary steering wheel, which was exhibited by the Admiralty. In itself it is a simple shaft upon two supports, having three steering wheels upon it, with a barrel of large dimensions between two of them. The wonderful part of it is, the disregard of the elementary mechanical laws involved in the increased diameter of the barrel prepared for the wheel ropes; and the apparent attempt to ignore the relations between space and power. Perhaps no better instance could be given, in its mechanical aspect, of the tenacity with which the Navy clings to things which are once established, even when all reason for their continuance has disappeared.

In former days, when speed was small, ships were short, and the area of rudders was much less than at present, three or three and a-half turns of the wheel admitted of a sufficient economy of power to enable the helmsman to put the helm hard over without difficulty. The measure of the increase of power put into his hands by the use of a steering wheel was, first, the difference of diameters of wheel and barrel, or ultimately, the difference between the space passed through by any single spoke of the wheel, and that passed through by the extremity of the tiller. If the movement of any single spoke through a space of (say) 18 feet, placed the rudder at an angle of 10°, however you might vary the mechanism connecting the wheel and tiller, you could never assist the helmsman one jot, except in diminution of friction.

In the days of sailing vessels, the long tiller connected with the wheel by a simple "whip" purchase, admitted of the helm being put over by 3 or 3½ turns of the wheel. When screw vessels came in, their peculiar construction necessitated short "yokes" in place of the long tillers. As there was here considerable loss of power immediately developed, the purchase of the wheel ropes became a gun-tackle; and as the area of rudders became larger, and the speed greater, the purchase upon the yoke became a luff. The number of turns upon the wheel which sufficed to put the helm over when the purchase was a "gun-tackle," were plainly insufficient when the purchase was a "luff." Instead, however, of increasing the number of turns upon the wheel, and so preserving the purchase gained by the luff, the powers

of those days proceeded to destroy it, by enlarging the barrel of the wheel! the total result being evidently a loss of power over the rudder to the extent of the extra friction given by the increased number of parts in the tiller ropes. Many of Her Majesty's ships are still fitted in this way, and, as a consequence take eight or ten men to steer them, when an appeal to the elements of mechanics would reduce the number to two or three. The Holyhead boats, for instance, which are, I believe, 300 feet long, and, of course, require great facility in steering, have but one helmsman in the open sea, and four when going in and out of harbour. But the power of each man over the rudder is more than double what it is in our ships; for instead of exerting it through $3\frac{1}{2}$ turns of the wheel, he exerts it through eight. I have been tempted to go more into detail in this matter in consequence of its great importance and direct application to many of our larger iron-clads now in commission. I read in the *Times*, for instance, that in order to put the "Minotaur's" helm up in 1 minute and 7 seconds, no less a number than 48 men were required: 30 at the relieving tackles, and 18 at the wheel. One feels that there is a waste of power somewhere, and the locality is at once indicated by the statement, that to give 40° of helm only $3\frac{1}{2}$ turns of the wheel were used.

Where there is little besides friction to overcome, simpler mechanical appliances may be employed; and consequently the apparatus exhibited as fitted to the "Bellerophon's" rudder is a return to the old tiller and "whip." There are a great number of arrangements for working rudders by means of racks and pinions, and endless screws—some of them of great ingenuity and practical value; but they nearly all are applicable to the smaller class of vessels only, and I have dwelt too long already over the principles of steering to do more than mention the fact.

The attention which is now bestowed on the sanitary arrangements of ships was well illustrated in the section of the "Nymphe," exhibited by the Admiralty. Here we saw the application of scientific knowledge to actual circumstance, where the hollow iron masts and funnel were made accessory to the promotion of perpetual change in the air of the bilges, holds, and lower parts of the ship.

Respecting the masting, rigging, and fitting of ships aloft, the English Admiralty showed nothing. The French Admiralty exhibited most of their models fully rigged, and the stump top-masts, strong square yards, and light wire rigging, showed very plainly the increasing conviction that the motive power afforded by the wind has sunk from its ancient high estate, to be the mere assistant of steam. The models exhibited by Admiral Halsted were fully rigged, and conveyed to the mind a counter idea, that the mast and yard had not yet retired from active service. So also in the magnificent models exhibited by the Thames Iron Works there was considerable provision for using sails.

The abundance of ships' iron-work and wire-rope exhibited, showed how greatly iron is superseding wood and cordage, and how it is gaining daily new territories.

There was a considerable display of cables, capstans, and wind-

lasses, but not much in the way of novel anchors, of which the Martin anchor in the English department was the chief representative. This anchor consists of a shank, very short iron stock, and moveable crown and flukes. Instead, however, of one fluke only taking the ground, and the other remaining above it, as in the Porter anchor, both flukes enter, and so give increased holding power. Provided this anchor is not liable to drag for some time before "biting," as was the case with the old Porter, and providing it is not more difficult to handle at the bows than the present form, the Martin anchor would appear to have manifest advantages.

In the matter of marine engines, the Admiralty exhibited those of the "Sappho," beautifully compact, and excellent in plan, as all Penn's engines are; and also a very beautiful model of the engines of the "Minotaur."

The French put into their shed by the Seine a complete, full-sized engine, with boilers, screw-shaft, and screw complete.

Perhaps nothing in the application of steam machinery to Naval purposes, is more remarkable than the recent and sudden growth of steam launches. How far the movement is likely to go, it is difficult to determine: but so immensely useful in saving labour and time are these little vessels, that I fully expect to see the principle carried further and into smaller boats than at present. Two pairs of steam-launch engines were exhibited by England, and some by France. England employs the twin-screw and France the single screw and single cylinder. The latter are the simplest engines, and when the French and English Fleets were together, it was generally admitted that the French launches were the more powerful of the two, but much of that superiority may have been due to build, for the French launches were specially built for steamers, while ours were of the old form of boat.

With respect to the iron and brass work of France and England, so far as it relates to marine material, it struck me that there was a very marked superiority of workmanship in favour of England. There appeared to be a greater precision, and greater truth of surface in most of the English work, but then, I think, on the other hand, that we put a much greater finish into our work, and it may be possible that this extra finish deceives the eye. If it is so, or if the work is equal in both cases previous to finish, it might be economy on our part to content ourselves with rather less of mere ornament.

The difficulties connected with the use of iron ships, received illustration in the many plans for sheathing their bottoms. There were no signs that that question had as yet received its final solution. The cost of most methods prevents their wide application, and the ideas most in favour, lie in the direction of mere paint or varnish, washed off from time to time, but efficient while adhering to the bottom. In my opinion, in war ships the expense of wood sheathing covered with copper, and carried well above the water-line, would soon pay itself, and, as I before remarked, the wood sheathing seems desirable for purposes of safety.

The subject of boat-lowering appears to have attracted much atten-

tion lately; there were a great many plans exhibited, the chief and best of which were Kynaston's, exhibited by the Admiralty, and Clifford's, exhibited by the proprietor. Both of these are too well known to need explanation. Others were, in principle, similar to Kynaston's, but were defective in being more likely to "go off at half-cock," or inadvertently, before reaching the water; a very serious defect. There are certain requirements in a good boat-lowering apparatus which, until some one succeeds in uniting them all, will still leave room for inventors. The crew lowered in a boat at sea have quite enough to do to look after themselves until the boat reaches the water; the lowering should therefore be done inboard. But the lowering should be in the hands of one man, and it should be impossible to lower one end of the boat before the other. It should then be impossible to disengage the boat till it reaches the water, which is equivalent to saying the water should itself do the work. Lastly, the lowering apparatus should also be the hoisting one; that it is not so, is one of the chief defects of Clifford's apparatus.

The English Admiralty were much more liberal in showing internal fittings of ships than any other Government. Magazines, sashes, scuttles, capstans, hawse-pipes, cabins, hatchways, lightning-conductors, channels, and many other fittings, were fully illustrated and capitally arranged for inspection.

A binnacle-compass, lighted from the top, on a very excellent plan of Mr. Nunn's, with what is called a "course-indicator," attracted a good deal of attention from its novelty and neatness. The idea of the course-indicator is to prevent mistakes in the courses given, so that the helmsman may have as it were, a fixed index pointing out to him the course ordered.

While on the subject of compasses, I must not omit to mention one of the cleverest pieces of mechanism in the building—I mean Captain Arthur's recording compass. It is so arranged, that a pencil attached to the card traces the course of the ship on a sheet of paper placed under it; thus every little variation is inevitably recorded. The use of such an instrument generally, would doubtless prevent us from hearing so much of those extraordinary currents which sometimes land a ship on unexpected coasts.

In the matter of signals, I thought I was about to learn something very new and interesting when I read an entry in the French catalogue as follows:—"No. 21. Apparatus for night lights and signals: scientific work, by the late M. Sudre;" but my hopes were dashed to the ground when I ascertained the apparatus to be two bits of wood nailed in the form of a cross.

Signals were, in fact, evidently at a discount in the Exhibition—or rather perhaps Captain Bolton and I took up so much space over them that no one else felt disposed to face us. The excellent Commercial Code, however, put in an appearance with models for instructing merchant Officers in its use. It is not generally known that the Board of Trade now compels all merchant Officers to pass in signals before receiving their certificates. We may therefore hope that there will not be hereafter that absolute want of knowledge which prevents mer-

chant ships from ever answering our signals at sea when we want information.

In the matter of ship's lamps there were only two exhibitors worthy of note, Mr. Nunn in the English department, M. Chatel in the French. The French have evidently been doing much in improving and simplifying the lighting of their ships. While we have numbers of patterns, some bad and some good, and wander far and wide for manufacturers, the French appear to have but one form of lamp, adaptable to all purposes, have only one manufacturer, to whom they pay a good price and from whom they get a very good article. I believe the lighting of our ships might be economised by some such arrangement, and I am not prepared to say that our lower decks are as well lighted as they might be for the same money; for I doubt whether we apply right principles to the attainment of our object.

The French bow and mast-head lights are very much more elaborate than ours, they are also much more expensive; but, so far as I have compared them, the simpler and cheaper lights of Mr. Nunn, which are supplied to our ships and were exhibited in Paris, are the best of the two. In one respect, however, the French beat us in logical action. We have somewhere picked up the idea that a small vessel is less likely to come to grief from collision than a large one, and we consequently provide them with less powerful bow and mast-head lights. Were the decision to rest with me, I should be inclined to say, take care of the small vessels, and the big ones will take care of themselves. If any difference is to be made let the smallest vessel have the largest lights. The French use nothing but brass and copper for the metal work of their lamps, and I believe they consult economy in so doing, for I was recently shewn a set of copper lamps which had been ten years in use in one of Messrs. Wigram's ships, and they were without a flaw, whilst I know that our cheaper tin lamps soon wear out from corrosion.

A novel application of air to engine-room telegraphs was Mr. Gisborn's pneumatic telegraph. It appeared to work admirably, and as the air was all enclosed, seemed quite secure from getting out of order.

The display of buoys, beacons, and light-house arrangement by France and England were certainly finer than anything which has appeared before; and in the park, the great iron light-house over the lake, and the Trinity House scaffolding for the electric light—two structures between which appeared an undying rivalry—will always remain in the minds of visitors as very remarkable features of the display. It was a satisfaction to me to see the electric light at length beginning to take its place as the proper source of light for light-houses, and I do not doubt that, provided no other cheaper light of equal power comes forward, the electric light will gradually supersede all present First-order lights. The occasional bellowing of the enormous fog horn in the park, warned one that the time is probably coming when a ship reaching the English Channel in a fog will go from sound to sound as she now goes from light to light, and so find her way on in safety in spite of thick weather.

The difficulty in compiling a paper like this, is to know what

to touch on and what to pass by. I have endeavoured to take something in the nature of a general survey of the Naval Department, without going too closely into any particulars. Properly speaking such a paper should be written on the spot, for only under such circumstances can it be made really interesting or valuable.

Taking the naval display as a whole, I must acknowledge to great disappointment. First at the paucity of display—except by France and England—but more from the scattered state in which Class 66 found itself. It was two or three days' labour to inspect any one branch of the class, owing to the distances necessary to be traversed, and for the same reasons, any comparison between the work of the different countries was extremely difficult.

But the English naval display, taken by itself, was as unique and perfect a thing as I ever expect to see. Europe generally owes to our Admiralty a debt of gratitude for the frankness with which we opened our stores of experience and naval knowledge to their inspection. But I think Europe will owe us another debt for a different reason. The "Admiralty Shed" was a harbinger of peace amongst maritime powers, for no Frenchman, Prussian, American, Russian, or Italian, could pass from their own displays to that of the English without some such reflection as this: "What will the power who displays such energy and resource in times of peace in our favour, be likely to do against us in time of war?"

Evening Meeting.

Monday, March 2nd, 1868.

MAJOR-GENERAL THE HON. JAMES LINDSAY, Vice-President, in the Chair.

NAMES OF MEMBERS who joined the Institution between the 3rd February and 2nd March, 1868.

LIFE.

Owen, John F., Lieut. R.A. 9*l.*
Ollivant, E. A., Lieut. R.A. 9*l.*
Jago, John, Major 74th Highrs. 9*l.*

ANNUAL.

Tyrrell, Avery, Capt. 5th W. York. Mil. 1*l.*
Grant, Wilmot, Lieut. Rifle Brigade. 1*l.*
Webb, F. E., Lieut. 28th Regt. 1*l.*
Campbell, W. S., Ensign Rifle Brigde. 1*l.*
Morrieson, J., Lt.-Col. ret. Indian Army. 1*l.*
Darley, W. S., Lieut. 5th Fusiliers.
Roberts, Wm., Lt.-Col. 5th Fusiliers. 1*l.*
Tippetts, A. M., Surgeon 5th Fusiliers.
Ormond, W. C., Lieut. 5th Fusiliers.
Wilson, Richard, Lieut. 3rd W. I. Regt.

FIELD ARTILLERY ON THE CONNECTED SYSTEM.

By Major W. H. Ross, R.A.

In pace, ut sapiens aptarit idonea bello.—Hor. Sat. II., 2.

A TAUNT applied to inventors has now become almost proverbial, namely, that they are as sanguine of their inventions as poets are said by Horace to be irritable. How indeed could it be otherwise? If inventors had not always been sanguine enough to combat the depressions and checks incident to invention, there would have been no inventions at all; and in this view the word "invention" becomes synonymous with the phrase "arts and sciences."

Now, all inventions may, or should be, divided into three distinct phases: 1st, the original idea; 2nd, the practical development of that idea; and, 3rd, the improvement of that development,—which last may evidently be carried through a succession of gradations until what may be taken as practical perfection is reached.

I have ventured to preface my paper on field artillery with these remarks, having reference to a seemingly distinct subject—invention—because I wish you clearly to understand, and to give me the benefit of the result of that understanding, that what I have to ask your kind attention to this evening, is an invention in only the first or second of these phases, and, therefore, as completeness is neither pretended nor to be expected in this stage, so critical depreciation should be limited.

It seems indeed to be an impulse of humanity as universal as sanguineness in inventors themselves, to attack, or what is commonly called "run down," an invention which is presented before our minds by another, and these two antithetical impulses are doubtless placed by nature herself in the human understanding, the one to, as it were, *compel* the inventing or originating mind to pursue and carry through all difficulties its conception, which has, in many cases, proved of inestimable utility to mankind; the other to criticise and dissect the subject presented with surgical *sang froid* and minuteness—an impulse which, on the other hand, has doubtless prevented or limited a waste of money on many occasions by the rejection of crude or impracticable inventions.

It follows therefore, as a postulate to the acceptance of these two propositions, that depreciatory criticism should be indulged in an *inverse* ratio to the magnitude and alleged completeness of the invention proposed, while the praise which cannot be withheld from a successful invention is accorded in a *coincident* ratio.

Thus, if I were to come before you with a field-gun, whose application, I alleged, would render the assemblage of squares of infantry or masses of troops tactically impossible, pursuit ineffective, and the fire from guns on the old system almost harmless, and if I failed to establish these points by absolute proof in your minds, I should have as little reason as Horace's animal painter to "deprecate the "laughter of my friends;" but if I merely, as indeed I do, propose by the trial of a system different from that established, to inaugurate experiments which may lead to important results if successful, but to no great loss if failures, I should expect criticism certainly, but not derision; dissection, but not mutilation of my proposal.

Be so good as to remember also, that I do not by any means bring forward my proposal as the best system of field artillery in case it should be found convenient or necessary to alter the present mode of bringing field-guns into action. It is the best that I have been able to think of, certainly, or I would not have presumed to bring it under your notice to-night, but many Officers doubtless both would and could improve my suggestion, or perhaps suggest a fresh and better system altogether themselves.

What I *do* assert with confidence, though some perhaps will call it

temerity, is that the present mode of dragging field-guns into action against an enemy, back-foremost, unloaded, and behind a cover of six of its own valuable horses three deep, is not only clumsy and slow, but unnecessarily extravagant in the exposure of men and horses to the enemy's fire. Again, as in the limber system, you cannot, or ought not, to bring your waggons under fire, the gunners, who for the most part sit upon them on ordinary occasions, must, of course, *walk*, and in that significant monosyllable old soldiers will at once see the paralysis of any rapid and decisive advance of artillery *en masse*, like that ordered by Napoleon at Wagram, when General Lauriston advanced with no less than a hundred guns *at a trot* from the reserve (a considerable distance) to attack the position of Adlerka. I don't know the means HE used, but where would the gunners of an English light field battery be after an advance of several hundred yards without waggons, at a trot? Certainly not with their guns; and when they eventually reached them, they would be too "blown" to work them for some time.

Now, let us look at a limbering gun. Here is a model, with four camels attached, instead of six horses, and the gun and limber, as you see, made on a very much larger scale than the camels; but it will do very well to illustrate what I have to say. You see how the cattle are placed, one before the other, and can easily imagine, if many of you have not actually seen, how a heavy *direct* fire of the enemy's artillery would strike the poor creatures, vulgarly speaking, "all of a heap." Now, if a General in battle gets into the awful scrape of having an enemy's battery opening fire on the flank of his artillery drawn up in line, he is deservedly censured. He could not well be in a more fearful position; but here is a *direct* fire converted into an enfilade one as regards artillery horses, simply from the way in which they are brought into action, and this *every* General *must* incur with his guns on the limber system. Look at these horses or camels now, and suppose yourselves to be an enemy against whom they are bringing guns into action. You see one covers the other. Do you think you could fail to hit them with your guns? and killing the leading horse, say with a round shot, you see how the one next to it, if not the one behind that again, would most likely be wounded and disabled by the same shot. To make this more clear, I will ask the gentleman in front of me to take hold of this string while I pull it until it resembles as nearly as possible a straight line, representing the trajectory of a shot. If now, I ask that gentleman to hold the string as far back as possible, you will see how even a shot fired at a considerable angle will traverse (or kill) two of my horses, and if you enlarge the range to the actual service one of 1,500 or 2,000 yards, you can easily imagine how this angle of mischievous fire might be much more enlarged, as the converging lines of a triangle tend more to parallelism the longer they are.

Now suppose me to be under a heavy fire from you, while I bring this gun into action. The first thing I have to do is to unhook the loop of the trail of my gun from the pintail upon the limber axletree bed. Now I am in action—and not at all slowly either—

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Fig. 1.

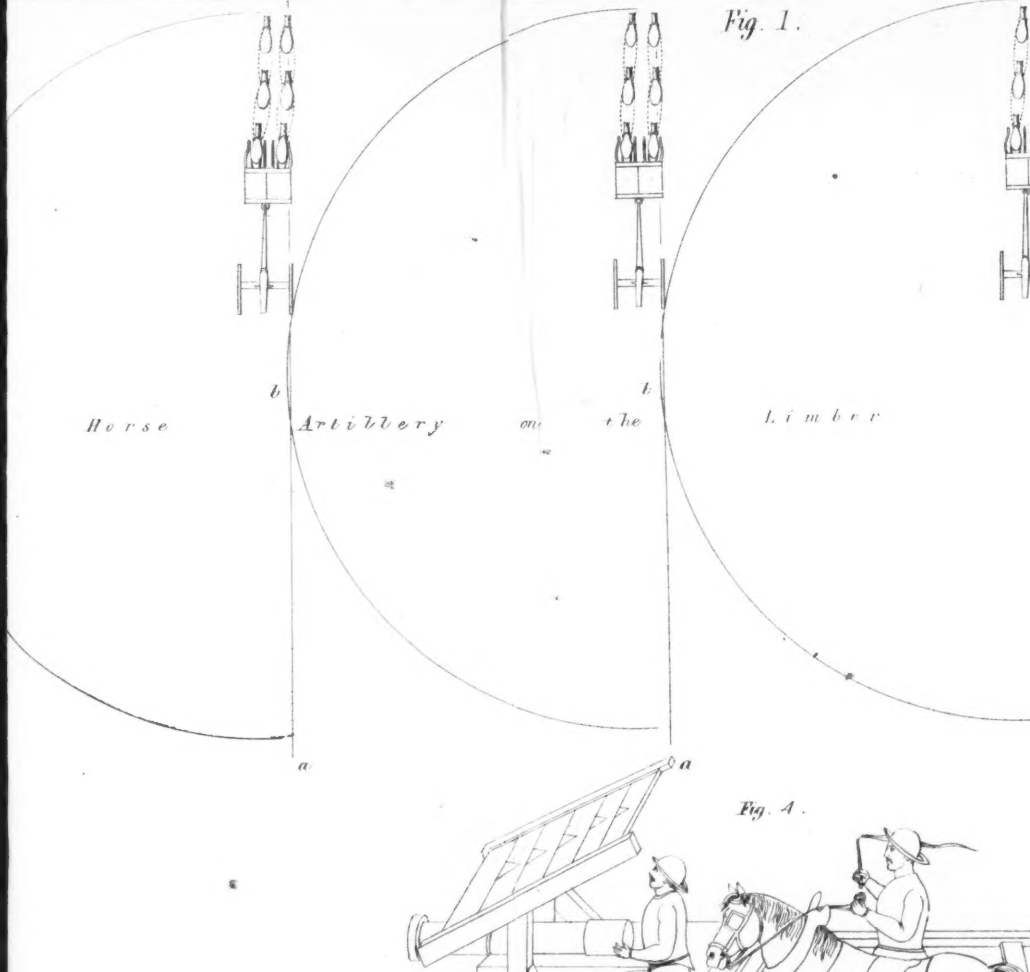
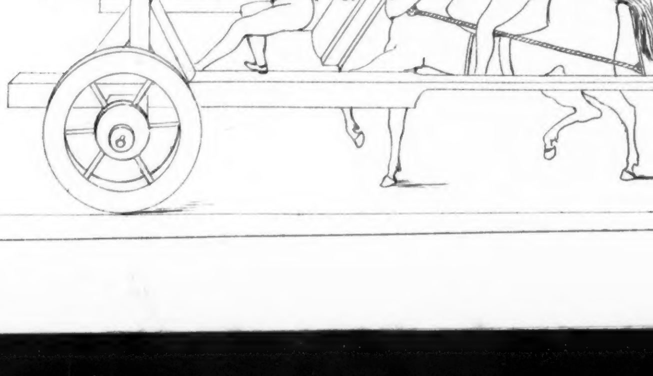


Fig. 4.



Pl. IV.

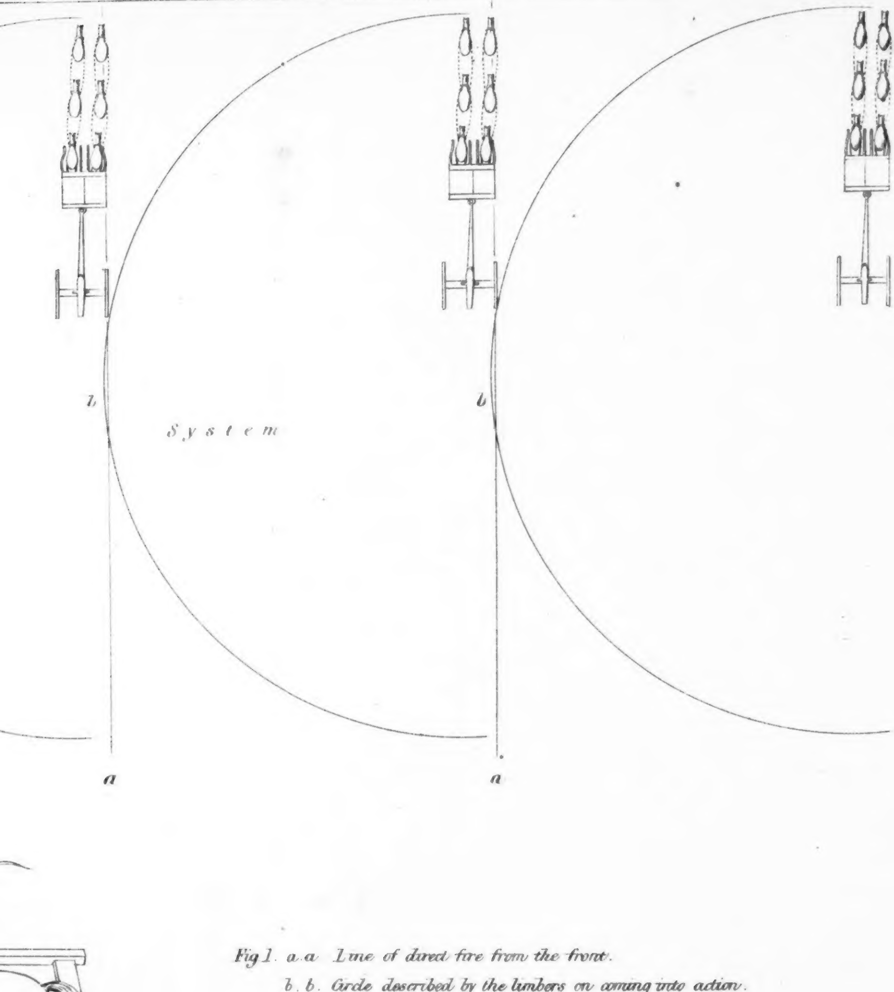


Fig 1. a.a. Line of direct fire from the front.
b. b. Circle described by the limbers on coming into action.

Fig 4. Gun Carriage, mantelet, gunner & driver of A.D. 1450

J. Jobbins

but unfortunately *it is to my own rear.* If you were only HERE I could pound you to pieces, but *my own troops are here,* I cannot, therefore, I fire in *that* direction. The second operation I have to perform under your fire is to bring round my limber and team to the rear. But you (the enemy) are by no means blind; you have been waiting for this very operation (which, by the way, was represented by one of the stuffed targets at Hythe), and now, as I expose the whole flanks of my six horses to you, you open upon them a deadly fire.* In the meantime the trail of the gun is brought smartly round, while one of the gunners is running after the limber to get a cartridge and shot out of it. The horses, if they have survived, are then brought up in their old dangerous position of three deep, some ten or eleven yards in rear of the gun, but you will see by this diagram (Plate IV) that the very same direct shots which would be liable to carry off three horses at once in their position of drawing the gun three deep, also form—not exactly a tangent, that would pass scatheless—but a minute chord to the arc of the circle formed by them in wheeling to the rear, in other words, it would again pass througe two or three of them!

Add to these serious defects those of advancing against an enemy's fire back foremost and unloaded, and you must allow the limber system of bringing artillery into action to be bad at the best.

But these military defects, although of course the most important, would seem to be by no means the only ones of the limber system of draught, the mechanical drawbacks being, if it was not a case of life and death, of almost equal importance.

I shall not presume to give my own opinions or surmises on this subject, but quote those of no less an authority than the late Sir I. K. Brunel. After stating that "however powerful may be the muscles of a limb, they must not be kept constantly on the stretch," and that, therefore the "resistance" of the draught must be such as to allow the animal to rest occasionally, Sir Isambard continues thus:—"Neither must it be a *yielding* resistance, as in that case the animal could not make any great exertion, for if he applied too much power, he would be liable to fall forward. . . . If a horse be made to drag a *rope* passing over a pulley, and descending into a well with a certain weight, say of 200lbs., attached to it, it is obvious that he could not make an effort greater than 200lbs. without instantly considerably increasing his velocity, *which would be a waste of power,* nor must he for an instant relax his efforts or fall below that mark, for he would then be unable even to resist the pull, and would be overcome by the weight. Such an extreme case as this, of course, is not likely to occur often in practice, but *the disadvantage of the principle is obvious.* The disadvantage of this kind of resistance is well known to carmen, though, of course, without consideration of the reason. A horse is said to pull better when *he is close to his work,* that is to say, when he is attached at once to the body to be moved, because every exertion he

*** Number 44 of the Journal of this Institution contains an illustration (Plate XVI), appended to Captain Majendie's paper on "Military Breech-loading Small Arms," which shows this very well, if we imagine the dots to represent cannon shot instead of rifle bullets.—W. H. B.**

makes is then communicated at once to the mass, but the leader of a team, unless he keeps the traces constantly on the stretch, may frequently waste a powerful effort without producing much effect upon the carriage. Another inconvenience resulting from harnessing horses in a team, or *one before the other*, is, that the leader, by tightening the traces, is constantly relieving the strain from the body horse, and reciprocally, the body horse from the leader, so that these horses labour under all the disadvantages of a long, elastic, and constantly yielding connexion with the load, which is not only fatiguing to them, but, in cases where the resistance is variable, prevents the full and united effect of their exertions being properly communicated to the carriage, for, if a slight obstacle, as a rut or stone in a road, checks the progress of the vehicle, the shaft-horse can immediately throw his whole weight into the collar, and the united effect of his strength and impetus is conveyed unimpared to the vehicle, and forces it over the obstacle, but if any elasticity is interposed between the power and the resistance, as in the case of the traces of the leader of a team, the whole or the greater part of the effect of impetus is lost, and that force which, if concentrated in one effort, would effect the object, being lengthened into a continued and comparatively feeble pull is insufficient. If we wish to destroy the impetus of a body moving with violence, we receive it with a yielding resistance. The action of catching a cricket-ball exemplifies this perfectly, and, therefore, if the full effect of momentum is wanted, *all elasticity in the direction of the movement should be avoided.*"

I do not feel inclined to apologize for the length of this quotation, when I think of the admirably concise language in which it is expressed, and that the facts it so forcibly and incontrovertibly demonstrates, are so powerfully in support of my proposed system of draught for field artillery.

Let us then here summarise the defects of the limber system of draught, not forgetting that of requiring such an enormous extent of ground to enable even one battery to come into action, as you will readily perceive from this diagram (Plate IV, Fig. 1), which is according to scale. You see that every gun requires a space of nearly twenty yards to enable it to fire at all! Putting then the military defects first, we have—

1st. Advancing back foremost and unloaded.

2nd. Covered by two rows of your own horses, three deep.

3rd. Exposing the whole sides of these horses again to the enemy's fire in unlimbering.

4th. Exposing them three deep *again*, while coming round to the rear.

5th. When in a position to move, not in a position to fight, and *vice versâ.*

6th. Each gun requiring the enormous space of 19 yards to enable it to fight.

7th. Inability to bring your gunners up with the gun at a trot, without also bringing your waggons under fire.

8th. By leading the recoil down to the earth at a sharp angle (the

trail), you require the carriage to be disproportionately solid, and therefore heavy, to resist such terrible shocks.

With regard to the mechanical defects of the draught, you have heard Sir Isambard Brunel's evidence.

Now, a few days ago, I put the question to a very intelligent member of the "advanced class" of artillery officers now about to pass at Woolwich: "I wonder who could have invented the system of dragging guns into action behind a limber?" and he, I thought, gave a very sensible reply—that it was probably merely the application to guns of the mode of draught used with heavy carts or carriages.

Having thus fairly stated what I consider the defects of the limber system of bringing guns into action, I have now to offer for your consideration what I venture to suggest as a remedy; but in doing so, I must again beg of you to remember that it is not by any means brought forward as a perfect system, or one without many and perhaps serious defects. It is for you to balance the two together and to decide—

1st. Whether the defects of the limber system are greater or less than those of the one I propose.

2nd. Whether the defects of my system—which will doubtless be presently disclosed as fully as I have done those of the limber system—outweigh those of the latter so far as to render it unworthy of experiments on a large scale.

This is a model illustrating my proposed system, it was made by an Indian native carpenter and a blacksmith under my superintendence, in 1863. I invite your inspection of it, but at the same time, I must caution you that it is not intended as an *exact* model of what a nine-pounder smooth-bore would be if mounted on such a carriage, but the principle is faithfully shown. I must therefore ask any gentleman who discovers *mechanical* defects—as, for instance, the probable weakness of the pin or pivot upon which the gun revolves between the wheels, and again, the effect of this in weakening the axletree and axletree bed, which could obviously be rectified in many ways, as by employing a breech-loader—I say, I must ask such gentlemen to remember that no pretension to *mechanical* completeness is made, and that they will find it more profitable to examine the *system* offered, than the mode of its execution in a model. I have been under the impression, since my proposal was brought before the notice of the Bengal Artillery Select Committee, in 1857, until a few weeks ago, that my idea of artillery draught was thoroughly original; but, very lately, in reading up the subject in Louis Napoleon's "Etudes sur le passé et l'Avenir de l'Artillerie," begun by him in the prison of Ham, and continued after he became Emperor, I lighted upon the drawing of which I have here made a copy (see Fig. 4). I ask your indulgence for the roughness of my sketch, as I am no draughtsman, and having to enlarge it to twelve times the size of the original—a process quite new to me—I could not hope to be very successful. However, here is the sketch, and although rough, it is a tolerably faithful copy. You see that the gun with its trail evidently remains horizontal when fired; the gunner is seated on the

plane of the axis of the bore, and the horse and driver are behind. So far the idea coincides with mine, and the gentleman who devised it can certainly claim the precedence, as he appears to have made this wonderful sketch (according to the Emperor) about the year 1450; but I do not think an examination of my model will show any further coincidence between the two, and, to tell the truth, I was rather gratified than otherwise at the discovery, for it shows me I am not so absolutely alone in this field as I thought I was. Still more gratifying to me are the following remarks, passed by such an eminent artillerist as the French Emperor, upon this very drawing. He says, this figure "représente un canon en marche, la bouche tournée vers l'ennemi, toujours prêt à tirer. Un mantelet (I have left this unmentioned, as it does not bear upon the design) qui devait couvrir le canonnier, le cheval, et le conducteur, était destiné à faciliter le moyen d'approcher de l'ennemi avec moins de danger. Mais, pour faire feu avec un canon attelé, il est nécessaire de limiter la force de projection de manière à réduire extrêmement l'effet du recul, c'est-à-dire qu'il faut sacrifier la puissance de la bouche à feu; *c'est pour cela que l'Artillerie n'a jamais réalisé depuis cette époque, les avantages très-désirables qui étaient cherchés dans ce modèle.*"

I shall come to this subject of the recoil presently; and you will see from the account I shall give you of the actual experiments made on my principle with an Indian bronze 9-pounder, loaded with a round shot and the service charge of powder, and fired limbered up, that His Imperial Majesty is quite mistaken in his conclusion that "it is necessary to limit the projective force of a gun fired in this position, in order to reduce that of the recoil."

You all, I fancy, see the absurdity of this figure, independently of the defects in perspective, &c., for which I beg to observe, by the way, I am by no means responsible. Supposing this tolerably brawny gunner to be firmly seated, instead of being apparently posed—like gravestone illustrations of cherubims—upon nothing, we have the horse harnessed between a pair of shafts having little or no support, to a splinter-bar, which forms part of the gun-carriage itself, and receives by a rigid connection the whole force of the recoil! No mortal horse could ever have been found to stand such treatment, and we may therefore safely conclude this drawing merely to represent a *design*, and not an actual gun and carriage in practical use. This fact seems to have struck His Majesty, from the expression he uses, of "the very desirable advantages sought to be gained in this *model*."

While upon the history of the subject of limbers I may mention a remarkable fact I have never seen noticed elsewhere: that is, that in the old drawings of sieges, &c., as for instance, in those illustrative of the English translation of Machiavelli's "Art of War," of which a curious black letter copy is to be found in the Royal Artillery Institution Library, dated 1610—we find *garrison* guns looking through embrasures, &c., *unlimbered*, with the trail on the ground, and *field* guns fired horizontally upon four wheels. We have now *exactly* changed this arrangement.

I need not repeat here that my system—of which I have here a

tracing of my drawing of 1859 (obligingly given me by Major Heyman, R.A., from the Select Committee Office), from which this model was made—is designed chiefly with the view of obviating the defects of the limber mode of draught above detailed. COUNT RUMFORD says, in his essay on "The Force of Fired Gunpowder," read before the Royal Society:—"The first step towards acquiring knowledge, is undoubtedly that which leads us to a discovery of the falsehood of "received opinions;" and, without making use of such a strong expression, I may, I hope, say without presumption, that when the first discovery was made, that the limber system of draught is radically wrong, I had advanced a considerable way towards rectifying it, for indeed, the chief difficulty I have to contend with is, not that the limber system is perfect, but that it is a "RECEIVED OPINION."

What I thought the first great defect of the limber system to be remedied, was the going back foremost against the enemy, and being obliged to break up the carriage, as it were, into two pieces before being able to open fire. In short, when ready to move, not being ready to fight, when ready to fight, not being ready to move.

Well, to have the muzzle of my gun pointed at the enemy during the advance, it was of course necessary to get the horses away from the front. Where were they to be put? I have placed four of them, as you see, in rear of the ammunition-box; the other two I place on each side of the gun in front. These I shall term, by way of distinction, the first "*propellers*," the second "*guiders*." These names will give you an idea of the work they perform, and if you will observe me, while I move the gun and carriage slowly to the front, this will become still more clear.

In order to allow the *direction* to be given to the right or left by the "guiders" or front horses, a joint must be placed (as indeed there is in all vehicles) in the front part of the carriage. I have placed it, as you see, in the thickest and strongest part of the trail, where it is at present locked by this pin attached to a chain to prevent its being lost. I remove this pin, and, as you see, the "guiders" can now move the front part of the carriage (sustaining the gun) freely to the right or left, as required, and so direct the passage of the piece to the front. These guiding horses are both mounted by riders, who obey the orders of the No. 1, conveniently seated somewhere on the carriage, to bring their "shoulders right" or "left," as necessary. They are, as you will observe, merely hooked to the side pieces of the carriage which protect them from the wheels, and are harnessed to swingle-trees strongly attached to the framework-arms, which enable them to revolve outwards to the extent of a semi-circle, or any *less* portion of the circumference. The "propellers," you will see, are placed so as to be protected or covered, not only by the gun itself and carriage, but by the ammunition-box (which is shot-proof). They indeed obviously enjoy an almost entire immunity from the enemy's *direct* fire. You observe that they also are harnessed, each horse to a swingle-tree, and each pair of swingle-trees to a strong pivot, which again is attached to a massive splinter-bar, which slides up and down the main pole. You will easily understand that by this means each pair of

horses can revolve outwards to the extent of a semi-circle on their own ground, in doing which, the inner horse will become the outer one, and *vice versâ*, but the "off" and "near" horses remain unchanged. It is of some importance to notice this, for the driver, as at present, will ride the "near" and *drive* the "off" horse, whether moving to the front or rear. The splinter-bar is locked to the pole by a pin passing through the iron collar, on which it slides up and down. The force exercised by the "propellers" in moving to the front, is thus carried along a *rigid* and *strong* line of stout wood and iron from the splinter-bar to the joint or point of direction of the carriage, where the draught is aided, and the direction maintained by the two "guiders." We all know how in natural philosophy the strength of the lever is increased by the distance of the force from the fulcrum, and in moving to the front, the pole and trail of this carriage are nothing more than a long lever, to which obstacles in front act as a fulcrum. This model is on the scale of about an inch to a foot; let us suppose then, this book, which is an inch and a-half thick, to represent a tabular stone or rising ground a foot and a-half high; this, if rising sharply, would be a very unpleasant obstacle to a team of horses harnessed in the present mode of draught, especially if moving at any pace. The wheelers would get the whole of the shock, the others pulling on an elastic resistance, but you see with how *very* slight an effort, pushing at the end of this long lever, I force the gun-wheels over this obstacle, of a foot and a half sharp obstruction. You observe how the gun-carriage turns partially in the shock, not meeting the obstacle fairly,—this is for want of the "guiders," who, of course, would spring upon the rising ground pretty nearly at the same time, and thus bring the gun-wheels *square* on to the obstacle. To show this, I will now lock the joint, by which means the lever is carried through the whole length of the carriage, and the propelling force applied to an obstacle at *right angles* to it, exactly as though the "guiders" were directing the gun in the same right line with the "propellers." You observe that the carriage surmounts the obstacle with still greater facility, and this facility is of course still further increased in proportion to the previous speed or momentum of the carriage.

We will now suppose a gun on the connected system having finished firing (or with any other motive) is to retire in action. This is effected,—instead of breaking the carriage into halves, one-half with the horses going left. the other half right about, gunners jumping down from their seats on the waggon, or running up breathless from where they have been left behind—simply by moving the *horses*, *not the gun*, which can continue its fire uninterruptedly. Let us begin an illustration with the "propellers"—though, of course in practice the thing would be done by *all* simultaneously—I wheel round, say the near pair on their pivot, thus—then the off pair: pulling out now the locking pin of the splinter bar, the whole back gently along the pole until the splinter bar is pushed back to the foot board of the ammunition box, the locking pin dropped into its new place, and these two pair of horses are ready to draw the gun to the rear. Similarly, the "guiders" are unhooked from their position along

the two side pieces, and, revolving outwards, are now facing the rear, ready to act in their new position merely as assistants in drawing the gun, harnessed on two outriggers. The gun and carriage is now ready to move to the rear, but the joint, or point of direction, must, of course, be changed. The front joint is locked by the pin before described, and the gun, *for the moment* unlimbered—for this gun *can* unlimber, if required. You observe, however, a peculiarity about this limber arrangement. There is, as you see, a double trail loop, and, of course a double pin tail on the limber axletree bed. By hooking up *both* loops, the joint is locked, by hooking one only, there is a joint, exactly in the same manner, and in the same place as the present carriages have it. Here you see, I have hooked one loop only, and the point of direction now rests with the propelling horses.

Another point to which I wish to call your attention here, is, that when my carriage is broken into halves or "unlimbered," horses (or motive power) *remain with each half.* This is an important advantage, for a gun carriage piecemeal, *i.e.*, two two-wheeled carriages, can thus be extricated much more effectually from heavy ground than one four-wheeled carriage could. If the Horse Artillery gun which stuck in the sand at Ramnuggur in the Punjaub campaign had possessed this power of locomotion, it would not have been lost.

The gun can now retire *in action* at any pace, in a position similar to what is called by sailors "a stern chase," or to the method known in battery drill as "retiring by the prolonge," which, as you are all aware, is simply a stout rope connecting the trail of the gun with the limber, so as to dispense with the operation of hooking up and unhooking every time it comes into action.

It is now time to show you how I propose loading and firing my gun in this position, and how the unavoidable shock of the recoil can be lessened, if not altogether obviated as regards inconvenience to men and horses.

The gun, you observe, is a muzzle-loader, although a breech-loader would answer the purpose better in every way, but at the time I first made my plan (1857), the breech-loading principle was inadmissible with the Select Committee, and it was a *sine quâ non* with inventions in guns, that they should be muzzle-loaders. I had therefore to allow this large space between the wheels to enable my gun to be loaded without the necessity of the gunners jumping down. It is loaded as you see *from* the rear, but *by* the muzzle; the gun being pulled round for the purpose by a lanyard attached to a ring in the muzzle mouldings, the vent being stopped by a plug of wood covered with chamois leather. You may easily imagine now, the gunner *kneeling* on the seat where he was sitting while the carriage was in motion (or in smooth ground, the gun could be loaded *while* the gun was in motion), and ramming down cartridge, &c., *over* the circular seat bar, the gun being elevated for that purpose, and to prevent danger in case of accident.

I have before stated, that I consider my ammunition box to be shot or shell proof, except in case of *vertical* fire, which could not well be received in a field of battle. I will now show you my grounds for this

statement. You see that it is *circular*, and opens, like an old fashioned snuff-box in two halves. It also revolves very easily upon rollers placed underneath. You may see how easily it turns or *gives* to a shock received from the outside. *Inside* there is a smaller circle, or in this case a decagon to allow for the fitting of elongated or rifled shot. You see, that the partitions for the shot and shell form, as it were, a *wall* of *iron* round the centre place which is intended for cartridges (or *powder*) alone, and thus prevent a hostile projectile from reaching the latter. *Prepared shells* being explosive, would always be kept in partitions in the REAR half of the box. The box is filled from the rear, so that when the ammunition of the *front* half is expended, the gunners have only to pull it round, and go on with that just placed in the other half. Thus, an enemy's projectile, besides the likelihood of its glancing off the round side of the box, which it would doubtless fracture, but that would only injure the solid iron shot inside—must, if it impinged upon it with any force, inevitably turn it round, and so increase the certainty of glancing off, besides which, it would have to penetrate a mass of cold iron a foot and a half thick before it could reach the powder.

When I showed this plan to Sir William Armstrong in 1859, he said "Why this is nearly the same idea as mine, but I think yours is the best of the two." His idea was to retain the present square or oblong ammunition box, but to place the shot in *front* of the powder as a protection, which plan has accordingly been adopted in the service, but I would ask your attention here to the fact that my ammunition box was submitted officially to the Principal Commissary of Ordnance, Bengal, in 1857, or *two* years before Sir William's plan was submitted.

Before quitting the subject of this box, I wish to remark the facility with which (having four horses attached to it, and being only limited by the *weight* as to the quantity of ammunition it can contain) this box could be sent to bring up fresh supplies of ammunition from magazines in the rear.

The next point to be examined is the comparative tactical capabilities of field-guns on the limber and connected systems. I have here a diagram (Plate IV, fig. 1) of two batteries, consisting of six guns each, on the two systems, drawn up on the same alignement, constructed on a scale of about one inch to five feet, the limbering battery being on the right.

The large semicircles, are the wheels the limbers are obliged to take every time the limbering battery comes into action to its front, for which purpose a space of nineteen yards is *ordered* to be kept between each two guns. The straight lines (*a a a*) represent the flight of *direct* shots coming from the enemy, against whom both batteries are supposed to be advancing. You remark the great difference of frontage, the limbering battery requiring 114 yards, the connected battery 34, the last being only the *depth* of a limbering battery with its waggons. Thus, *every limbering gun* requires a front space to bring it into action in which can be placed in line according to the present regulations, 28 file or 56 men of the infantry, or 19 file equalling 38 troopers of the cavalry. It will perhaps be argued that

these spaces between the guns have the advantage of allowing many shots to pass scatheless which would be received by a connected battery, upon which in fact the enemy's fire would be more concentrated. This, which seems at first a plausible objection, is easily demolished. In the first place, artillery on the limber system is always betrayed to the enemy *per se* when advancing, or not actually engaged, by this very open space which it requires. Looking through a telescope, you cannot possibly mistake a limbering battery for any other arm, and accordingly you proceed to demolish it during its advance, while a connected battery, especially if, as might very well be done, it had say half a troop of cavalry between each subdivision, could not be distinguished as artillery until it had commenced to open fire. *Secondly*, if *concentration of fire* be dreaded, there is nothing to prevent the enemy concentrating their whole fire on each gun isolated on the limber system, successively, until it was absolutely disabled. *Thirdly*, the connected battery can always, if required, open its intervals to *any* distance and have soldiers of other arms between, but the limbering one *cannot close* them to more than 19 yards *clear* interval, or thereabouts, without paralysing its power of coming rapidly into action. Again, a glance at this diagram will at once show that there are many natural and artificial objects on service—a mound, a farm-house, a few hay stacks—behind which such an easily handled compact mass as a connected battery could be effectually protected from the enemy's fire, while it would be difficult to find 114 yards of cover for a limbering battery.

Two-thirds of the horses of a connected battery, *i.e.*, twenty-four out of thirty-six, are, as you have seen, protected almost absolutely from the enemy's fire both in advancing and retiring, but what is the case with regard to the limbering horses? You see here, as I have before shown, how it is quite possible for the *direct* shots of the enemy not only to pass through *three* horses during the advance, or when drawn up three deep eleven yards in rear of the gun in action, but also while the limbers are wheeling to the rear in order to allow the guns to come into action.

When we turn from defensive to offensive considerations, I submit that the value of having guns on my system is still more marked. As a limbering battery occupies more than *three* times the space of a connected one, it follows that you could place three batteries for one, or eighteen guns for every six in the space allowed to field artillery at present; and when one considers that almost the chief value of artillery lies in a possible concentration of its fire in a general engagement, this fact is of very great importance.

Among minor advantages, I reckon the very great facility with which connected guns could be handled, compared with limbering ones. Any Officer who has commanded a brigade of the three arms on a field day, must have felt how awkward the guns are to work compared with the other branches. On the other hand, artillery Officers often with reason, complain that they receive orders applicable to infantry or cavalry, but very difficult if not impossible, for artillery to execute. As Captain of a horse field battery in India, brigaded with infantry and cavalry, I have myself been considerably puzzled how I was to carry

out orders like the following:—"The line or brigade will retire 10 or 12 paces and halt, front." Now nothing can be easier than for infantry or cavalry to "halt front" on their own ground, but for a limbering battery, which is 34 yards deep, to do this, it not only requires to advance some 40 yards to the rear of the proposed alignement before coming about, but to keep the interval of a division (19 yards) to the right or left, in order to enable it to come up square. A connected battery on the other hand, could retire and "dress up" to any new alignement with the same facility as cavalry or infantry.

It now only remains for me to notice the RECOIL, on which account alone, according to the Emperor of the French, "artillery has never been able to realise the very desirable advantages sought," by advancing against the enemy, *face* instead of *back* foremost. I have before stated, that the shock of the recoil can be greatly lessened, if not altogether obviated by mechanical means on the connected system, where the axis of the piece is maintained in a plane practically nearly horizontal with the surface of the ground, and indeed, as the carriage is slightly depressed towards the rear, the gun will in fact require very considerable elevation to make its axis horizontal with the plane upon which the wheels travel, *i.e.*, the *direction* of the recoil. This will be more apparent if I lay the gun of this little model point blank, and then turn its side towards you. You see, it appears now to be slightly depressed, whereas in reality it is about point blank. If I now unlimber the gun, and drop the trail on the table, it is no longer level with the ground, but elevated, at a very considerable angle. To reduce this angle, I have to elevate the breech, or, in other words, weaken the resistance of the elevating screw. But as the centre of gravity of the gun and carriage in this position is obviously *below* the axis of the piece, in which direction of course the recoil, that is the force of the elastic gas of the fired gunpowder back from the bullet, is transmitted, the whole would obviously, if unchecked, have a tendency to revolve round its movable centre on being set in motion by the recoil. This centre is of course the axletree of the carriage connected with the gun by its trunnions, and, if it could be so balanced that the trail could be just supported and no more, the gun and carriage on being set in motion backwards, would begin a revolution upon this axis—thus. Now, what checks this tendency to rotate round the axletree? Why the *point of the trail touching the ground*, and if the shock were strong enough, and nothing gave way, this last, forced into the ground, would form the centre of rotation, and the gun and carriage tilt right over it—thus. This destructive effect on the carriage of course increases with the angle of elevation. Now the shock thus given to the carriage carried down to the very earth itself at a sharp angle by the trail, may be imagined, if not actually measured, by supposing a case in which the earth would offer no resistance whatever to the point of the trail, but allow it to slip backwards on a level plain with the full force of the recoil. Strange as it may seem, such a case actually occurs in the service of our artillery in Canada, where guns are occasionally fired on "glare" (which I suppose means very smooth) ice. The recoil in such a case, according to General

Lefroy's admirable "Handbook of Field Service," is from *twenty* to *thirty* yards! The weight of the gun and carriage is not mentioned, but they must be for field service. Now, if this recoiling force, thus expressed in *yards*, be converted, as it easily could, into *pounds avoirdupois*, some idea would be conveyed of the strain our field gun-carriages have to bear, and, as a practical proof, I have often observed at target practice with my battery (an Indian 9-pounder smooth-bore one, with carriages of teak, assimilated to the Royal pattern) that the axletree-boxes, especially of the howitzers, were broken nearly every round; and in one piece I remember standing in rear of, I could see the cheeks of the trail open perceptibly outwards when the gun was fired. Unfortunately too, the stronger, that is heavier, a carriage is made, the greater will be the strain upon it, for the greater of course will be the *inertia* requiring to be overcome by the force of the recoil.

Now in my connected system, the centre of gravity of the whole system (gun and carriage) is evidently very much altered. It is much *higher* and nearer the plane of the axis of the bore of the piece; there is therefore little or no tendency, on the application of the recoiling force, for the gun to *rotate* round its axletree. The force is now carried to the rear in a line parallel with the axis of the bore, in which course it is first of all softened by the friction of its wheels on the ground and axle-tree arms; and it is next received upon the two buffers, which you perceive here fitted in the direction of the recoil. This movement does not affect the *guiding* horses, as the framework slides, as you see, backwards and forwards upon the two side pieces, thus, while the weight (or inertia) of the heavy ammunition box is interposed between it and the *propelling* horses. I will now fire this little model loaded with powder only, in the two positions referred to, as an illustration of what I have here advanced, but I must first mention that the springs of these buffers have been made very strong —too strong to show anything like their proper action with a small charge of gunpowder, such as this little gun can contain.

With reference to this subject I may mention, that I think the subject of recoil, as exhibited by our field guns in action has yet to be philosophically considered and calculated. You are of course aware of the mode in which Count Rumford measured it, by means of an apparatus devised from Mr. Robins' velocity pendulum. He swung his gun horizontally by two pairs of trunnions from the roof of the coach-house of an English gentleman with whom he was acquainted, thus reducing the resistance by friction practically to nothing—the rising arc of recoil was then measured by a graduated ribbon hanging loosely, but quite extended over a table underneath.

But the question is, do the results from the recoil of a piece, whose centre of gravity was in the axis of the bore, and where the resistance from friction was *nil*, and the inertia of the *gun* only to be overcome, afford satisfactory data for calculating the effects of the recoil of a piece fired under the conditions of a field gun unlimbered? Do you not think, for instance, that an apparatus, something like this model, carrying, say an Armstrong 12-pounder, the wheels running on per-

fectly level tramways of polished steel, would be more likely to give us results more available for practice?

A couple of experiments will show you what I mean. You see the gun which I have here detached, carries a couple of horizontal buffers, which, of course would be of a certain strength, and the pistons graduated. I now load the gun, and sprinkle with this brush a little flour over the pistons, which sticks to the oil with which they are covered. I now replace the gun, and mark the point of contact of the wheels with the surface of the ground. With the full-sized gun this would be done by having a scale graduated on both the tramways, besides which, the whole gun and carriage would of course be accurately *weighed.* I now fire the gun, which you see has moved backwards a very little, and examine the buffer pistons, the flour on which will of course have been pushed back to the extent they have been moved up into their cylinders. These will not show any mark, because as I said before, they are too strong for this model. If then, the extent the *wheels* have travelled may be taken to represent the *inertia* of the gun and carriage + the friction, the space cleared from flour of the buffer-pistons will show the actual momentum of the recoil.

I now unlimber the gun, and after preparing it in a similar manner, fire it again in the new position. It is obvious that by a number of experiments of this kind on a large scale, the actual recoil of guns under almost every condition of actual service can be ascertained. I have a memorandum here of 13 rounds fired with this model (I will not take up your time in reading it, as it is never safe to reason up from experiments with models or small arms to the probable effects of firing large guns), which shows however, a curious fact, that on a perfectly level polished mahogany table this little model loaded with only half a charge, recoiled as to the *wheels*, *forward* instead of *backward*, half an inch.

I will now conclude by reading from this paper a short account of some experiments conducted at Ferozepore in 1858, with a 9-pounder, carriage and limber (Indian pattern), lent to me by the late Lord Clyde for experimental purposes; my battery, however, having been ordered to Peshawur, I was not able to conduct the experiments myself, or even to be present at the time.

"My dear Ross,—I must tell you the result of some experiments made by Mr. Coates with the 9-pounder gun you borrowed from the magazine, which I witnessed a few days ago. The gun was lashed to its limber with rope, the loop being in contact with a block of lead fastened on the limber axle bed. The gun was loaded with round shot, and a service charge of powder. Mr. Coates fired the first round while sitting on the gun carriage seat, without any material inconvenience to himself —the recoil was 7 feet in a very smooth level plain. Several rounds were then fired by Mr. Coates while sitting astride of the beam, the wheels being sometimes blocked to prevent the gun moving, and sometimes allowed to recoil—the result was satisfactory. Two rounds were fired by Mr. Coates while the gun was in motion towards the rear, the result being equally satisfactory. In one instance, I and Serjeant Mann sat on the limber boxes while the gun was being fired, and we experienced no inconvenience. There is no doubt that if the recoil were resisted by buffers, as you propose, the gunners could, with perfect ease, sit upon the gun carriage and limber."

Mr. Coates says regarding this experiment:—

"From the first trial without a buffer, it is evident that buffers can be omitted, though no doubt the shock can be done away with entirely with them."

At the second experiment, Mr. Coates substituted for the sheet of lead on the limber axletree bed, of which I had never approved, although I remained long enough at Ferozepore to remark that he intended trying it,—an attempt at the execution of my original proposal, which was to place buffers or springs in such a position in the carriage, that they would not only serve to resist the shock of the recoil of the gun, and take it off the horses, but also cause the draught to be more easy to them by having a great part of the whole weight to be pushed as it were, divided from them by these springs. Mr. Coates, however, committed *two* faults in the execution of this design, which, with the badness of the materials used, which were old and worn out, caused, as is detailed, "the greater part of the gearing to give way" on the first shock. His first error was in using a spring of so many plates of steel, that, for the purpose of resisting the recoil of a gun, which, it will be remembered, is essentially a quick, powerful, and sudden stroke or blow,—his spring was in fact no spring at all, but a mass of almost solid iron, much less impressible than the sheet of lead he had formerly used. His second error was in placing his buffer behind, instead of before the limber axletree bed. Captain Lewis thus describes this second experiment to me:—

"I don't recollect exactly how the springs were fixed, and my drawing is not very clear. The buffer did not act, the springs were, I think, too stiff, and from the action of the recoil not being quite direct upon the spring, the axle bed was split to pieces; however, Coates managed to fire a few rounds while the gun *was being propelled to the front by about twelve European gunners, at a considerable pace;* they were of course brought up sharp, but none of them were thrown down."

Mr. Coates referring to this partial failure, says:—

"I did it up hastily, and the first fire some of my gearing gave way, and I suspended the trial and set to work doing it substantially, and next week hope to give you the details of the experiment with a buffer."

Neither Mr. Coates nor Captain Lewis state the number of plates of which this spring was composed, but they must have been very great, as Mr. Coates in a letter to me detailing the final experiment, soon after, says he even then used 20 plates to his buffer; this letter is dated 14th June, 1858, and says:—

"I have just had a fair experiment with the buffer; it was made of four buggy springs or twenty plates, but three springs would have done better. I had a number of Artillery Officers seated on the limber boxes, and myself on the gun axle seat; I had the whole driven to the front by men at the pace of a good trot, and fired repeatedly, and the shock was not so strong as to require you to hold anything, therefore this problem is solved most satisfactorily. I now propose to have a trial with horses as soon as I can get ready; in. the meantime I am going on with my model of the gun and steering apparatus."

Captain Lewis says of this third experiment that—

"The result was so far satisfactory, that the shock to men sitting on the carriage and limber when the gun was discharged, was much less than it would have been without the buffer, but the gun recoiled almost as much as when first limbered up and without buffers; I think the recoil was from 5 to 7 feet on a very smooth level plain."

In 1865 Sir William Mansfield lent me another similar 9-pounder and carriage, but as he soon after removed me from the horse battery which I commanded, I was again unable to carry out any experiments on the large scale, and was, therefore, reluctantly compelled to return the gun into the arsenal at Allahabad.

I have omitted to mention that of course, if convenient, guns on the connected system could be drawn by horses on the line of march, or, where preferred, in the usual way, the peculiar arrangement I propose being reserved for the field of battle.

My chief aim has been to avoid anything like *complicated machinery*

to effect the purpose of guiding to the front, &c., which those who have been, as I was, at Chillianwalla, under a fire of 100 guns, firing round shot, we opposing them for half an hour, with only *one* battery of 10 heavy guns, well know to be *utterly inapplicable* to artillery on service.

At the eleventh hour, as I was leaving Woolwich this morning, I found the following paragraph in Count Rumford's essays:—

"The iron 18-pounder constructed at Munich was intended for covering troops retreating before an advancing enemy, and is so contrived that it can be fired without stopping, or while it is *in full march.* It has, indeed, often been fired, and very quick, too, while the horses which drew it were in full gallop. The carriage, which is upon four wheels, serves at the same time as our ammunition waggon, and also for carrying the men who serve the gun. These, however, are only three in number, and more are not wanted.

"I had contrived a gun on these principles which could be fired *advancing* as well as *retreating* in full march, but as I am not now writing a treatise on artillery, it would be improper for me to enlarge further on the subject,"—p. 216.

I have only now to thank you for the patient manner in which you have listened to me.

Table of Results of Experiments on Recoil with Model.

Round.	Charge.	Wheels, Movement of.	Buffer Movements.	Remarks.
No. 1 C.*	$\frac{1}{2}$	$1\frac{2}{8}$ inch	No mark	On table. *Forward.*
2 C.	Full	$\frac{5}{8}$ inch	Do.	Table.
3 U.	Do.	Not moved	Do.	On ground, trail embedded.
4 U.	Do.	Do.	Trace	Do., right wheel and trail embedded.
5 U.	Do.	Do.	Do.	Do., right wheel and trail embedded.
6 U.	Do.	Do.	No Mark	Do., trail marks.
7 C.	Do.	Moved back about $\frac{1}{2}$ in. and then forward to old mark	Do.	On ground.
8 C.	Do.	*Forward* $\frac{3}{8}$ths	Trace	Do., gun at an angle to right of about 30°.
9 C.	Do.	1 inch	Do.	On table.
10 C.	Do.	$\frac{3}{8}$ths inch	Do.	Do.
11 C.	Do.	$3\frac{1}{2}$ inch	$\frac{1}{16}$th inch	On ground, loaded with *a long wooden shot.*
12 C.	Do.	$2\frac{1}{2}$ inch	$\frac{1}{16}$th inch	Do. Do.
13 U.	Do.	Trail stopped	$\frac{1}{8}$th inch	Do. Do.

C—*Connected*: U—*Unlimbered.*

The CHAIRMAN: We are very much indebted to Major Ross for having brought this subject forward. I know perfectly well, from having worked a brigade, the extreme inconvenience which results from the great length, from front to rear, of the gun and its appurtenances, and from the gun always pointing to the rear, having to be brought round with a long train of horses to get it into action. The difficulty in the plan before us, appears to me to attach to the breadth of the gun-carriage with the side horses.

Major ROSS: This is a muzzle-loader.

The CHAIRMAN: But still with a breech-loader you would have a horse on each side.

Major ROSS. Yes, on each side; but you could reduce the width of the gun carriage.

The CHAIRMAN: It is not often you meet with roads wide enough for horses on either side of a gun carriage.

Major ROSS: It requires four yards only; but you could always adopt the limber draught in marching.

The CHAIRMAN: If you wanted to bring your gun into action, could you alter that arrangement, and have your horses on each side?

Major ROSS: Yes, certainly.

The CHAIRMAN: Then that does away with the difficulty that occurred to me. I was thinking of the breadth that the guns would occupy.

Major ROSS: This model is too broad to show my plan properly: it is broader than there is any necessity for. The present guns are 5 feet, from tire to tire; and my carriage would only be 6 feet—1 foot more. It is the horses that would make the extra breadth, but they are not required on the side while on the march.

The CHAIRMAN: It is quite plain that if you can always carry your gun pointing to the front instead of to the rear, it would be an immense advantage.

Major ROSS: An immense advantage in every way.

LECTURE.

Friday, March 13th, 1868.

Colonel the Right Hon. THE EARL OF LONGFORD, K.C.B., Under Secretary of State for War, in the Chair.

MODERN ARTILLERY AS EXHIBITED AT PARIS IN 1867.

By Lieutenant-Colonel C. H. Owen, R.A., Professor of Artillery, Royal Military Academy, Woolwich.

The subject upon which I have been requested by the Committee of this Institution to read a paper to-day is—"Modern Artillery as exhibited at Paris in 1867."

No doubt many of you visited Paris last summer, and I am sure that all who did so, must have been much struck by the evidences there shown of the progress made in the manufacture of military weapons since our last Exhibition in 1862. The question has often been raised, as to whether military arms and appliances, intended solely for the purposes of destruction, should be allowed space in an Exhibition devoted to the display of those things which have been contrived with a view to increase in every possible way the preservation, comfort, and material prosperity of mankind. I do not, however, propose to discuss this question, since it has been practically solved by the reception of munitions of war into these International Exhibitions, in which the gradual development of modern artillery can be traced to some extent.

In my report on the artillery exhibited at Paris last year, I took each country, and described the guns, carriages, and other *matériel* shown in the department allotted to it, the object being to give any one visiting the Exhibition, a tolerably accurate catalogue* of what was to be found, and where to look for any particular object. Such a plan would, however, be totally unsuited to the present occasion, involving as it would do a tedious amount of detail, with the greater

* The ordnance were not catalogued, except those in the British department and a few others dispersed at random among the different classes in the general catalogue.—C. H. O.

part of which you are doubtless familiar. I shall content myself with endeavouring to point out the present condition of the artillery armaments of the chief great Powers.

In order to simplify the subject, I shall divide it into the following branches:—

Ordnance.
Carriages.
Ammunition.

In speaking of ordnance, it will be unnecessary to give a detailed explanation of the different materials or methods of construction, or of the various systems of rifling and loading, as all these have been so frequently described and discussed within these walls. I myself had the honour of reading a paper here three years ago, in which I attempted to consider each of the above questions separately, and as it has been printed in our Journal, it would only be waste of time to repeat what can easily be obtained if required.

I shall, therefore, to-day merely draw your attention: 1st, to the particular materials and constructions; and 2ndly, to the systems of rifling and loading, adopted for the ordnance of different services.

The ordnance shown by our War Department were, with one exception, a 10-inch cast-iron mortar, all built up, the smaller natures of wrought-iron alone, but the three heaviest guns, of wrought-iron exterior, with a steel inner tube. They were built up on the Armstrong method of construction, except a muzzle-loading 64-pounder, in which the Fraser modifications have been carried out.

Mr. Fraser's plan of manufacture has very great advantages over the Armstrong method; for besides the reduced cost and saving of time, a very much stronger construction is obtained by the double or triple coiling and welding together several portions, so as to have but few pieces in a gun. The liability to separation of parts, a manifest defect in the original Armstrong construction, and which was lessened by the introduction of Mr. Anderson's hooks and recesses, is very much reduced, if not practically prevented in the Fraser guns.

There is every reason to believe, that we have now, by grafting the Fraser modifications on the Armstrong construction, and by the employment of steel for the inner tube, arrived at a very satisfactory stage in the manufacture of heavy ordnance, combining as it does great strength and endurance with moderate cost, and protection by the wrought-iron exterior from dangerous results, should fracture of the barrel occur.

The 12-inch or 600-pounder rifled gun was the most powerful piece exhibited that had been subjected to proof, and we must not forget that our first 600-pounder, of 13·3 inches calibre, made by Sir W. Armstrong several years ago, has fired more than 200 rounds, some with very large charges of 90 lbs.

Until lately 400 rounds were considered as the limit of endurance of our heavy built-up guns when fired with battering charges; with ordinary charges, which caused little or no *scoring*, a far greater number can be fired without injury to the piece, but the scoring or guttering commences, and rapidly increases with battering charges

(of powder like our own), unless the rush of gas over the shot is prevented. By plugging up the vent when the scoring had increased to a dangerous extent, and drilling a new vent, the gun being reversed, the limit of endurance can be nearly doubled. Recent experiment has, however, shown, that by placing a wad between the cartridge and base of the projectile, the scoring can be prevented, or at least very much lessened, even with battering charges, so that we may confidently expect that the heavy rifled guns we are now making, will prove as durable as the old smooth-bored ordnance. I could give you instances of 9-inch guns having stood 500 battering charges without sensible injury, and of 9- and 7-inch guns which have been fired over 1,000 rounds. Sometimes you will hear of service guns giving way, but on inquiry, it will be found that they were made several years ago when the manufacture was but imperfectly developed, and the materials not so good as those now used.

In the Annex devoted to private British exhibitors, three methods of construction were illustrated—Armstrong's, Whitworth's, and Palliser's. Two Armstrong built-up guns were sent from the Elswick Works, one a 9-inch, with a coiled iron inner barrel, and the other a 12-pounder, with a steel barrel. The Whitworth Company exhibited built-up steel guns, and some smaller pieces, which were solid forgings, with separate trunnion rings. In the built-up guns, the outer portions are pressed on by hydraulic pressure, instead of by shrinking, as in the service, or Armstrong guns. These Whitworth guns possess no doubt great strength and endurance, so much care being taken in the testing of each portion, and in the whole manufacture, but being made entirely of steel, they must necessarily be very expensive, and more dangerous in case of fracture, than those having wrought-iron exteriors. The largest of them is only a 7-inch gun throwing a projectile of 150 lbs. Major Palliser showed a 9-inch gun made of a coiled iron interior, with an outer jacket of iron cast over it, and which had been subjected to the test of 111 rounds with heavy charges and projectiles. You are all no doubt aware that he has for a long time advocated the utilisation of smooth-bored cast-iron guns for rifled ordnance, by boring them up and inserting a coiled wrought-iron barrel, and some of such converted pieces have stood severe tests. I think that Major Palliser will find his chief difficulty with large ordnance, in getting coiled barrels sufficiently sound to stand heavy charges. However, he is going to state his own case to you shortly, and I for one shall be very glad to hear his latest views and proposals with regard both to the conversion and manufacture of heavy guns.

Let us now consider how the French make their heavy ordnance. They, like the Americans, have adhered to cast iron, contenting themselves with improving the manufacture and strengthening the guns with exterior rings or bands. We in this country have little confidence in ordnance so made, if required for firing heavy projectiles with large charges, the results of our own experiments and the failure of the Parrot rifled guns at the siege of Charleston, and the bombardment of Fort Fisher in America, having proved their liability to burst in spite of the strengthening rings. The French heavy guns are hooped with

Canon de 24 c/m

Fig. 1
Section showing Steel Rings

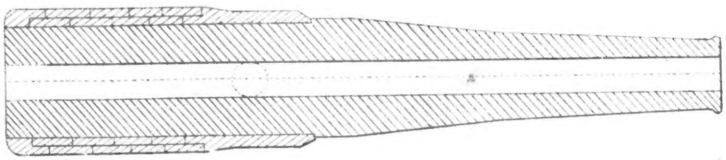


Fig. 2.
Breech open
(Part of saddle removed to show form of Breech Plug)

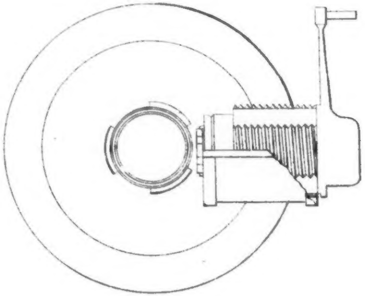
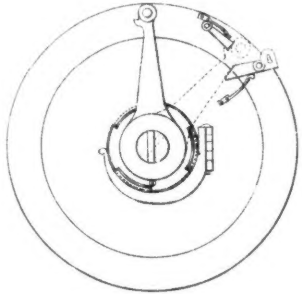
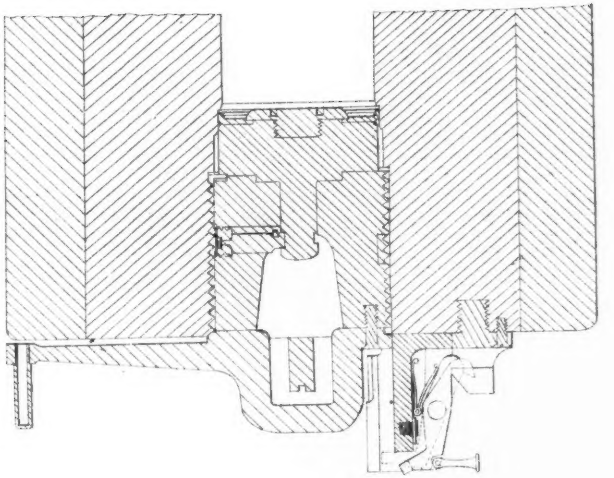


Fig. 3.
Breech closed



Pl. V.

Fig 4
Breech closing Arrangement



J. Jobbins.

steel rings, supplied to the Government by MM. Petin and Gaudet, the pieces being cast at the Imperial Foundry at Ruelle; they are cast hollow on a sand core. The rings may not at once give way on fracture of the cast iron beneath, but they will not prevent this fracture, and if they should fail, would fly to pieces like cast iron (Plate V, fig. 1).

The weights of the projectiles and charges put down for battering purposes are rather heavier than those used for our heavy rifled ordnance of nearly similar calibre, the French guns being also rather heavier than ours; but it must not be forgotten that the French powder burns more slowly than our own, it is not so pure, and gives less initial velocity; 25 lbs. of English powder being equal in these large ordnance to about 35lbs. of French. With every deduction in strain due to the comparative weakness of powder, I can hardly believe that these large rifled guns of cast-iron, although strengthened with steel hoops, will stand any number of battering rounds. It is, however, but fair to state, on the authority of a French Naval officer, that one of these guns, the *canon de* 24 cm. of 9·45 inches calibre, has fired 1,002 rounds, the last 650 being with 318lbs. projectiles, and 53lbs. charges. This case alone is of little value as to the endurance of similar pieces, for it is well known that unstrengthened cast-iron guns will occasionally exhibit the most extraordinary endurance, but if it can be repeated several times with different ordnance, their construction may be considered reliable. The advantages claimed by the French for their system of manufacture, are facility and rapidity of production, and very small cost.

Besides the rifled guns, a monster 16·5-inch smooth-bored breech-loading piece, made in the same way, was exhibited. It is intended to fire a 660 lbs. spherical shot with a 110 lbs. charge, and weighs 39 tons, or 16 tons more than our 600-pounder rifled gun. Nothing can be learnt of its performance, and it was doubtless made like the 1,000-pounder Krupp, expressly for the Exhibition. Being a smooth-bored gun, with a charge no greater in proportion to the shot ($\frac{1}{6}$) than those of the rifled guns, it is quite, if not more likely, to stand than they are, supposing the casting to be equally sound, which is a more difficult matter with such an enormous mass.

The ordnance that next claim our attention, are those which were exhibited by M. F. Krupp, of Essen, in Prussia. The enormous scale on which M. Krupp's works are conducted will be understood, when it is stated that they cover about 450 acres of ground, about one-fourth of which is under cover; that the number of men employed is 8,000, besides 2,000 more in the coal mines at Essen, at the blast furnaces on the Rhine, and at the iron pits on the Rhine and in Nassau; also, that during last year the produce of the works was 61,000 tons, by means of 112 smelting, reverberatory, and cementing furnaces; 195 steam engines, from 2 to 1,000 horse-power; 49 steam hammers, from 1 to 50 tons (the blocks): 110 smiths' forges, 318 lathes, 111 planing machines, 61 cutting and shaping machines. The establishment has already delivered 3,500 guns, valued at over £1,050,000, most of them being rifled breech-loaders from 4 to 300-pounders.

The 1,000-pounds sent by M. Krupp, was the largest piece in the

Exhibition, that had never been fired. It is a built-up steel gun, with forged inner tube strengthened by rings forged from ingots without welding, and took sixteen months to make, working day and night. We thought £4,000 a very heavy price for our first 600-pounders; what Government would be likely to pay £15,750 for those 1,000-pounders? No purchaser is, however, required, as the monster gun has been generously presented to the Prussian Government.

Next in size to the 1,000-pounder was a 9-inch gun forged in one mass, with the exception of the trunnion ring, from a steel ingot. This, and a 6-inch gun are splendid steel forgings, and were stated to have been subjected to the test of firing, the former 120 rounds with 45lbs. charges, and the latter 100 rounds with 12lbs. charges, but the weights of the projectiles were not given. Some 8-inch steel guns supplied to the Russian Government by M. Krupp were found to stand over 400 rounds, and the 4-pounder field guns exhibited were stated to have fired increasing charges up to $3\frac{3}{4}$lbs. and 122lbs. shot. There can be no question that the Krupp's steel forgings are admirable, and confidence appears to be placed by both Prussian and Russian Governments in even the very large ones for ordnance; but besides their enormous expense, it is at present doubtful whether uniformity in quality can be obtained in heavy masses of steel, the danger to be feared being, that while some will stand enormous and continued strains, others may fracture suddenly like cast-iron, breaking up into numerous pieces without warning. Many of even the small Prussian field guns burst during the late German campaign, but this was attributed by M. Krupp to the defects in the breech-loading arrangement.

Other steel guns were exhibited by different German manufacturers, but they were generally of small calibre; and a few steel blocks for guns were sent by Russia where three steel factories are being established by the Government.

Sweden showed two heavy cast-iron guns, one, which was rifled, being hooped with steel. I could, however, obtain no information about them.

The United States of America sent none of their powerful smooth-bore ordnance,* but we have little reason to regret their absence, since our own Government has procured one, at the suggestion, I believe, of the enlightened President of the Ordnance Select Committee, Brigadier-General Lefroy, the performances of which you have all, no doubt, watched with great interest. The guns manufactured on the Rodman plan are magnificent castings, and, as we all know, most formidable pieces for short ranges. They have also, no doubt, been produced at a comparatively small cost. It is not easy to ascertain what has been done lately in the way of rifled ordnance in America, but the following statement occurs in the "Annual Report of the Secretary of War," for 1866. "The experiments which have been carried on at "Fort Monroe Arsenal, to test the power and endurance of the 8-inch "and 12-inch rifle guns, made of cast-iron by this department, are

* A table of them was given in my last lecture, and will be found at p. 358, vol. ix, of the *Journal of the Royal United Service Institution.*—C. H. O.

"highly satisfactory, and warrant the belief that cast-iron rifle guns of "these calibres may be introduced into the military service with safety "and advantage. The 12-inch rifle throwing a projectile of 600 lbs., "and with 55 lbs. of powder, has been fired 390 times. It is believed "that no rifle gun of this calibre has ever given so great endurance. "The further trial of these guns will be continued." With regard to the latter part of this passage, I will remind you, that 55 lbs. is a very small charge for a 600-pounder. We have fired charges of 90 lbs. from a 600-pounder, although 75 lbs. will probably be the limit in future. Besides this, however, we must remember that 55 lbs. of American powder is equal to very little more (about 45 lbs.) than the quantity of English powder used with our 9-inch guns. I do not mean to deny the formidable power of the American 600-pounder, but to point out that with a charge of little over $\frac{1}{12}$, 390 rounds is no great performance after all.* In fact, I believe our smooth-bored cast-iron guns would, if rifled, stand charges of $\frac{1}{12}$ or even $\frac{1}{10}$, without being either strengthened or lined.

I have chiefly dwelt upon the materials and constructions for heavy guns, since for small or moderately sized pieces, up to 5 or 6 inches' calibre, no difficulty is experienced in getting the requisite amount of strength and endurance. This was sufficiently proved, although pretty well known before, by the Armstrong and Whitworth experiments, the guns made for which stood over 3,000 rounds, some of the last being with large charges and increasing weights of shot, air spaces being left between the cartridges and projectiles, so as to test the guns as severely as possible. Except in our own service, and in that of Prussia, bronze is still employed for field guns. The Dutch Government exhibited some of their old smooth-bored, cast-iron and bronze ordnance converted into rifled guns by lining with bronze.

If we now turn to the questions of rifling and loading it will be seen that there is much diversity of opinion among artillerists respecting the relative advantages of different systems. In our own service, the smaller natures of rifled guns are breech-loading, with soft-coated projectiles, and the larger pieces and very small mountain service guns, muzzle-loading with projectiles provided with studs, the general opinion being also in favour of the latter system for small as well as large rifled ordnance.

Mr. Whitworth adheres to his modified hexagonal bore with hard projectile, but Sir W. Armstrong accepts the Woolwich system of rifling for his large pieces.† Mr. Mackay's method of obtaining rotation, by placing sawdust between the cartridge and shot, was not represented.

In France the smaller rifled guns are muzzle-loading with studded projectiles, while the heavy are breech-loading also with button projectiles. In the Dutch, Belgian, Spanish, and Swedish services muzzle-loading guns with button projectiles are used. In Prussia and Russia

* It has been stated that the 20-inch American gun has been fired with 200 lbs. charges, and 1,100 lbs. shot (*Army and Navy Gazette*, 22 February, 1868).—C. H. O.

† Sir W. Armstrong is now supplying the Austrian and Italian Governments with heavy ordnance, made on his principle and rifled on the Woolwich system.—C. H. O.

breech-loading with soft-coated projectiles is employed for both light and heavy guns. In Austria the guns are muzzle-loading, but the projectiles have soft coatings with projecting ribs to fit the grooves in the bore of the piece.

With respect to different systems of rifling, which have occasioned so much confusion and mystery, I will repeat what I said here before, that the system is not of such very great importance; good results as regards accuracy of fire may doubtless be obtained with most of them, if both guns and projectiles are manufactured with equal skill and care. The great thing after all is to get a strong and enduring gun, and then to adopt a system of rifling which shall fulfil the following conditions:—

1. Simplicity.
2. Non-liability of projectile to jamb either in loading or firing.
3. It must not entail too great strain.
4. But will allow of the use of large charges.

It will not be necessary to say anything about the two Armstrong systems of *breech-loading* in the service, and I will therefore confine my remarks to a description of the French and Krupp systems, which were exhibited in Paris.

The bore of the French gun is closed by a steel plug, with a thread in its exterior surface, fitting into a screw in the breech of the piece (Figs. 2 and 4). The thread does not extend round the plug, but it consists of three separate equal portions, which together cover one-half of the surface of the plug; the thread is removed from the three intervening spaces, and this is also the case in the breech. The plug can therefore be easily entered, its screwed portions passing up the plain surfaces in the breech; but when pressed home and turned through an eighth of a circle, the threads of the plug enter those in the breech, and the plug is secured in its place. To prevent the escape of gas, a steel cup, which requires changing after about 200 rounds have been fired, is attached to the front of the breech plug, but does not turn round when the latter is screwed in or out.

The plug, when withdrawn from the gun, is supported on a saddle or tray attached to the breech by hinges, so that it can be turned round through a quarter of a circle to allow of the piece being loaded. The projectile is loaded in a bearer, which projects over the screw to prevent its being injured, and is guided into its place by means of a directing groove extending through the chamber to the rifling. A seaweed wad is inserted between the shot and charge. The lanyard passes through a movable eye attached to the breech, and cannot be pulled until the plug is home (Fig. 3). The eye is kept down by a spring, so as to nip the lanyard, until the lever, which screws the plug into its place, has been pressed down, and coming in contact with the eye, raises it. This system of breech-loading, which is used for the four naval rifled guns and the monster smooth-bore piece, is said to work easily and to be secure.*

* The French have an iron-clad vessel, purchased I believe from the Americans, which mounts four of the 27-cm. guns.—C. H. O.

Krupps Cylindrical Wedge

9 inch B.L. Gun

Fig. 5.
Horizontal Section

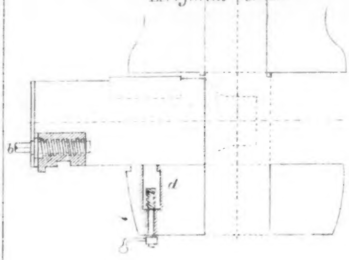


Fig. 6.
Side View

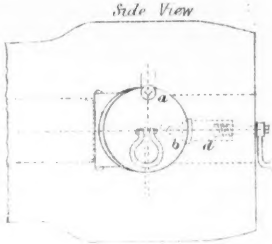
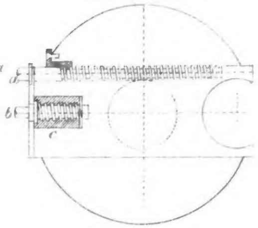


Fig. 7.
Vertical Section.

a Screw for moving wedge in or out
b Screw for tightening wedge
c Nut for tightening screw
d Catch pin



Krupps semi Cylindrical Wedge,
B.L. System
(for Field Artillery).

Fig. 8
Rear of breech

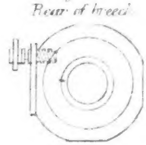


Fig. 9
Side of breech

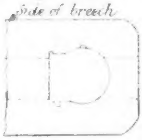
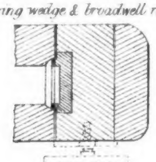


Fig. 10.
Section of Breech
(showing wedge & broadwell ring)



J. Johns.

M. Krupp showed several systems of breech-loading, two of which are novel and well worthy of notice. One of these breech-loading arrangements was in the nine-inch gun, and the other in a four-pounder, and in both there is but a single wedge. The apparatus in the nine-inch gun consists of a simple cylindro- or round-backed wedge, the flat front surface forming the bottom of the bore (Figs. 5, 6, and 7, Plate VI.) It can be quickly moved in or out by means of a screw in the top of the wedge, working half in the latter, and half in a nut let into the metal of the gun above. To force the wedge completely home, another screw in the back of the wedge is, however, necessary. The nut in which this second tightening screw works has a certain amount of play, right or left, but it can be rendered immovable by the head of a catch-pin, behind the wedge and at right angles to it, being screwed forward into a slot cut in the back of the nut. The nut being thus fixed, after the wedge has been nearly brought into its place by the first screw, the point of the tightening screw pushes the wedge home. A shot bearer is attached behind the breech, through which a wooden loading box, with the projectile in it, is inserted, and the shot thus prevented from catching in the wedge-slot. It is said that the Russians have adopted this system of breech-loading for heavy rifled ordnance. The advantages claimed for it are simplicity, uniform distribution of strain, no angular surfaces, and strength. When I saw it in the Exhibition it could be easily and rapidly worked, of course without being fired. The escape of gas is prevented by the use of a copper cup, placed in after loading. When lately tried in Austria, the copper cups were not found to answer; but by substituting the Broadwell ring for them, this breech-loading arrangement answered perfectly.*

The breech-loading arrangement of the four-pounder differed in several respects from the nine-inch (Figs. 8, 9, and 10). The wedge is round behind, but rectangular in front, and works in a slot running across the breech. The wedge is provided on the left side with a screw turned by a lever handle; this screw works into a thread running across the breech over the wedge, which is brought into its required position by turning the handle. A locking-pin drops down from the top of the breech into a shallow groove in the upper surface of the wedge, and keeps the latter securely in position. On the face of the wedge is a steel (Broadwell) ring, which, when home, fits against a similar ring in the bottom of the bore, and prevents the escape of gas. This appears to be a very simple and excellent arrangement, and can, no doubt, be worked with facility and safety.†

* "The breech-loading apparatus, in the first guns sent by Krupp, did not " answer all just demands as the copper cups required the greatest attention and did " not prevent the jamming entirely, but since the introduction of Broadwell's ring, " which remains serviceable far beyond a hundred rounds, prevents entirely every " escape of gas with its elasticity, and requires no attention at all, Krupp's *Rundkeil* " *verschluss* is really perfect." (Extract of a letter from Count Kielmansegge, an Austrian Naval Officer.) The Broadwell ring gave perfect satisfaction in Russia.—C. H. O.

† A Russian general officer informed me that his Government were casting a large number of bronze field guns, which would have the breech-loading arrangement of this 4-pounder.—C. H. O.

There were several guns exhibited having the Wahrendorff and other breech-loading arrangements, but these need not detain us.

I will now say a few words on gun carriages, in the materials and constructions for which, many changes and modifications have lately been introduced. As our ordnance have increased in size and weight, greater strength has been required in the carriages, and additional mechanical appliances for working them with facility. The necessary conditions—strength, durability, facility of working, and control of recoil—are obtained without difficulty in a carriage for a gun of comparatively small calibre; but for pieces weighing many tons, and firing heavy projectiles with large charges, it is no easy matter to combine these conditions. By the substitution of wrought iron for wood, sufficient strength and durability, without unwieldiness, can doubtless be secured; and it must have been noticed in the Exhibition that wood has been entirely discarded as a material for the gun carriages of heavy ordnance.

Much attention having been devoted in England to the question of muzzle-pivoting, it was disappointing not to find any carriages on this principle, or even designs or models, either in the War Office annex, or in that of the private British exhibitors, although several excellent models were shown by Prussia and Austria. There were some small models to illustrate Captain Heathorn's method of muzzle-pivoting in the building of the British naval exhibition, but being small in size, and not properly labelled, they may not probably have attracted much attention. Mr. R. Mallet, C.E., who has paid so much attention to artillery matters, and is the author of the able work, "The Physical Conditions involved in the Construction of Artillery," proposed some years ago several designs for muzzle-pivoting, and more recently a carriage contrived by Lieutenant-Colonel Shaw, R.A., for a 68-pounder, has been tried with success. There were also no models or drawings of another carriage on an entirely novel principle, and which appears to offer several advantages. I allude to Captain Moncrieff's counterpoise carriage. It will not be necessary for me to describe it, as the inventor has himself explained the construction here. I will only state that a carriage is now being made in the Royal Carriage Department, under the personal superintendence of Captain Moncrieff, and that we shall all, I feel sure, look forward with great interest to the results of experiments with it. Should such carriages work satisfactorily, batteries can be made for them without embrasures or shields.

It will not be necessary for me to describe our service iron carriages, their construction, the compressor arrangement, and other details having been explained here; besides, there are, no doubt, many in this room who, having been at Woolwich, Shoeburyness, Portsmouth, or the Paris Exhibition, have had ample opportunity of examining them. I will only then remind you that we have numbers of excellent wrought iron carriages for our heavy rifled ordnance, that garrison carriages of the same material, but of lighter construction, have lately been adopted for 64-pounder rifled, 32-pounder, and 8-inch smooth bored guns, that we possess iron sling waggons for moving our heavy guns, and that steel carriages for the small mountain guns were lately sent to Abys-

sinia. Sir W. Armstrong exhibited an iron field gun-carriage which had many excellent points, besides a box-girder carriage for his 9-inch gun.

The wrought iron carriage for heavy rifled ordnance shown by the French had box-girder brackets, but the method of elevating the gun, and of giving compression to the carriage, differed from ours.

The breech of the gun is supported on a chain suspended between the brackets, this chain can be raised or lowered by turning two handles, one outside each bracket. The compression is given on both sides by a brake of gun-metal embracing the side piece of the slide, the thickness of which increases from front to rear, so that the compression becomes greater as the piece recoils.

M. Krupp showed the wrought iron field carriages* used in the Prussian and Russian services respectively. Spain also showed models of field gun carriages, sling waggons and carts, and devil carriages, all of wrought iron.

It only remains to consider the ammunition now used by artillerymen. This term *ammunition* includes an enormous quantity of stores and projectiles of all kinds, besides fuzes, cartridges, wads, and tubes, but I shall only refer briefly to those which have been recently introduced taking it for granted that you are familiar with the rest.

In the first place there are the Palliser projectiles, both shot and shell, employed, as you are aware, for the penetration of iron defences, for which purpose they have answered so remarkably well. As a material for firing against thick iron armour, ordinary cast iron is useless, breaking up without producing injury. Wrought iron is too soft, a great proportion of the work on impact being expended in flattening out the shot. Steel answers well, but is enormously expensive. The essential feature of the Palliser projectiles is that, being made of carefully selected brands of iron and chilled in casting, they possess *intense hardness*, the property requisite in projectiles fired at iron plates with high velocities. Besides, however, this property, they have a pointed (*ogival*) head, which both theory† and practice appear to prove is the most favourable form for the penetration of iron masses. An additional and most important advantage is the cheapness of the manufacture of these projectiles, their cost being about one-fifth of that of similar steel projectiles. The steel projectiles shown by M. Krupp and others had also *ogival* heads.

In the next place is the Boxer shrapnel for rifled ordnance, in which the essential features of a shrapnel shell are embodied. Such a shell fired from a rifled gun having, previous to breaking up, a rotatory motion, considerable lateral spread is given to the bullets when released, and in the segment shell this is increased in consequence of the charge being in the middle of the shell.

In the Boxer shrapnel the charge is placed in a chamber at the base,

* The unwieldy carriage of the 1000-pounder was a mere bed.—C. H. O.

† General Mayefski, of the Russian service, has written a mathematical memoir on this question which was reviewed by Mr. Mallet in the early numbers of the *Engineer* of 1867.—C. H. O.

so that on explosion there is no tendency to increase the lateral spread of the bullets, but rather to impart higher velocity and therefore to give greater penetration. A tube leads the flash from the fuse to the bursting charge. The shell is filled with bullets of lead imbedded in rosin. The spherical form and density of the bullets are better for range and penetration than the angular form and light material of the segments.

The Austrians have also shrapnel shell on the same principle, with the bursting charge at the back of the shell.

The ingenious rocket lately proposed by Mr. Hale, and now adopted into our service was also exhibited. In the base are three vents, and round one side of each vent is a circular metal plate projecting about two inches from the base; when the gas issues from the vents its pressure on the plates causes the rocket to rotate, and gives its longer axis stability during flight, thus avoiding the necessity of using a stick. These rockets are very accurate in flight.

Before leaving this part of the subject I must also remind you of the Boxer life-saving apparatus, consisting of a double rocket, which is intended when fired to carry a line to a wreck. You will probably have noticed in the newspapers that by the employment of this apparatus many lives have been saved during the late storms.*

Before concluding, I must say a few words respecting the Gatlin Battery, which attracted considerable attention in Paris. It consists of a frame, mounted on a gun-carriage, and supporting six rifled steel barrels, which can be made to revolve, so as to bring each in turn opposite a chamber, by a handle at the side of a cylinder behind the chamber. In the cylinder is the mechanism for firing the cartridges, which is effected by the blow of a pin on a portion of detonating composition in the base of the cartridge; and an extractor advances as the barrels turn and withdraws the cartridge-cases. Twenty-five charges placed in a tin case drop one after another into the chamber through a gun-metal guide above; one battery throws bullets of about ½ lb., and a smaller one bullets weighing 1¼ oz. The battery is intended to fire a continuous stream of bullets towards the same point, and thus to supply more effectually the place of an ordinary gun, throwing case or grape shot. General Gilmore reported favourably on a somewhat similar weapon, called a *requa* battery, used at Charleston; it had twenty-five barrels, which, by means of a lever, could be diverged so as to scatter the balls according to the range. The effect of the fire of the Gatlin battery is said to have been far greater than that of a 24-pounder howitzer, when tried in America; but at Shoeburyness this superiority (over the case shot of a 9-pounder rifled gun) was confined to very short ranges. Like all weapons constructed for continuous fire, the Gatlin batteries might prove very formidable in the defence of short flanks, breaches, bridges, streets, and other confined situations, but can never supersede ordnance for ordinary war purposes.

In the brief review I have given to-day of the present condition of

* 14 persons saved at Poor Head, county Cork, 3 men rescued at Holyhead, and 11 persons at Bardley, Yorkshire.—C. H. O.

artillery, I have been compelled to omit many things which I should have liked to have touched upon, one of these being the chronograph contrived by the Rev. F. Bashforth for ascertaining the respective velocities of a projectile at different points of its trajectory. If any of you wish to see a brief description of this instrument,* and a more detailed account of the guns, carriages, and ammunition exhibited at Paris, you will find them in my Report on the Exhibition.

I have not attempted to go into the question of iron defences,† as the time allowed is barely sufficient to consider very briefly the subject of artillery. I will only make one or two remarks with reference to them. It certainly does seem strange that, although possessing so many fine iron-plated vessels, we have as yet no adequate protection in the way of floating batteries for harbour defence; batteries I mean that are invulnerable to the fire of any guns which can be carried by sea-going vessels. As regards land defences, batteries might also be made, without difficulty, shot proof, but this has not yet been done. It is to be hoped that the failure of the Gibraltar shield will prove a lesson to those intrusted with the construction of our fortifications, and prevent them in future from ignoring the results of experiments for the sake of a false economy.

In conclusion, I think it is only fair to bestow a few words of praise on the artillery *matériel* exhibited by the War Department. Notwithstanding the harsh criticisms, amounting in some cases to pretty strong abuse, passed not unfrequently in this country upon those intrusted with artillery matters, our Government did not disgrace itself, but on the contrary displayed an exhibition of ordnance and their appliances, which was most complete and perfect in every way, and admirably arranged for inspection. I can say this without fear of being accused of self-praise, for I am not employed either at the War Office, in a manufacturing department, or on any Committee, and my work at the Royal Military Academy rather tends to encourage a critical spirit. At the same time, having myself conducted a great deal of gun practice, both on service and at home, having had the best opportunities of witnessing the progress of military manufactures and also of watching all the experiments in connection with them, I can hardly be accused of presumption in giving an opinion upon the state of our armaments.

I will not however merely give you my own opinion, but will remind you of the praise bestowed upon our war munitions by an eminent civil engineer, Mr. John Fowler, who when presiding at the annual dinner of the Institute of Civil Engineers, in May last year, thus expressed himself, "I cannot refrain from one word of reference—and I "do so with pride—to the collections of munitions of war and specimens "of marine engineering, which are now displayed in the English de-"partment of the French Exhibition. I confess that the conclusion

* Mr. Bashforth has printed a full description of his chronograph (published by Bell and Daldy 1866).—C. H. O.

† A number of iron targets, which had been fired at, were exhibited by the British, French, and other nations.—C. H. O.

"which I drew from my examination was this (and I hope all other "examiners will draw the same conclusion), that it would be a wise "and prudent thing to be at peace with that country and that people "who can supply such munitions of war."*

I think that we may be well satisfied with the present method of manufacturing our ordnance, which promises to ensure strength and endurance at a moderate cost. Our systems of rifling, except the shunt, which is confined to a single gun,† may also be said to be satisfactory. No one accustomed to artillery practice would deny that our rifled ordnance, both breech-loading and muzzle-loading can be served with ease and security, and that their fire is exceedingly accurate. I do not say that they have no defects, or that equally satisfactory results might not have been obtained in other ways, and at a less cost, or that improvements may not be adopted with advantage; but that they are good serviceable weapons, and in all probability quite a match for those that may be opposed to them, no one competent to give an opinion would, I think, deny.

The question of breech-loading for heavy ordnance intended for cupolas or casemates may perhaps be not yet finally settled; and although I should be sorry to see the introduction of fresh systems into the service, circumstances might arise to create a demand for heavy breech-loading guns, and I confess that I should like to see both the French and Krupp's (latest) systems tried in this country.

Neither with our carriages nor our projectiles need we be dissatisfied, but much remains to be done in the investigation of the best descriptions of powder for our large rifled guns, and in the simplification of our *matériel* generally, which in these transition times is like that of other powers who have done anything lately, far too complicated. Every effort should be made to reduce the numbers of different natures of ordnance and projectiles with their accessories, for in a service like ours, scattered all over the world, a complicated *matériel* cannot possibly be understood, or therefore efficiently employed. Simplicity is also essential in the design of a gun, a carriage, or anything else intended for military purposes, for with complex constructions, the most trifling circumstances may render an apparently perfect mechanism utterly useless.

Frequent changes for the sake of trifling improvements or advantages have for the last few years been the bane of the Service. They were chiefly attributable to a cause that no longer exists, although minor ones still continue to operate to some extent. The complication in our *matériel* is no doubt mainly due to the fact that we have been passing through a transition state; but it must not be forgotten, that just when an able and responsible chief was required, there was no Director-General of Artillery, or other principal officer entrusted with the important charge of *matériel;* that the Superintendent of the Gun Factories was summarily got rid of, and replaced by an inventor and Government contractor (a very able man, I acknowledge, and one to

* *Times*, 9th May, 1867.
† The muzzle-loading 64-pounder.

whom we owe much), who was made virtually Director-General of Artillery; and that all the experience of the service was set aside, as if a gun had never been made, or at least fired. The wonder is that our munitions of war are not more complicated, and that we have not sacrificed more millions upon them, but it is satisfactory to know that efforts are now being made to simplify our military stores.*

Although then we may, I think be well satisfied with our own armaments, we must not fail to keep a strict watch on those of foreign powers, and to provide amply against them, in order that we may be able at any moment, in these threatening times, to defend our country, to protect our commerce, and to maintain our present high position among the nations.

* 55 different natures of smooth-bore cast-iron or bronze ordnance (guns, mortars, howitzers, and carronades), varying in size from 10″ calibre to ½-pounder, have recently been declared obsolete. There still remain in the service about 62 different natures of smooth-bored cast ordnance from 10″ to 3-pounder besides the two large built-up smooth-bored guns. There are 12 different breech-loading and 10 muzzle-loading rifled guns in the service. The ammunition is necessarily more complicated, every fresh gun added to the service entailing the supply of several projectiles, cartridges, &c. There are 22 fuzes of different kinds, not counting several patterns of the same fuze; besides these, there are 4 fuzes, of which no more will be made, but certain numbers of them are still in the Service.—C. H. O.

RIFLED ORDNANCE OVER 6-INCH CALIBRE EXHIBITED IN PARIS IN 1867.

Gun.			Calibre.	Weight.	Charge. Service.	Charge. Battering.	Projectile. Weight.	Projectile. Bursting charge of shell.	Remarks.
			inches.	tons. cwt.	lbs.	lbs.	lbs.	lbs.	
British Service.	Muzzle-loaders.	12-inch ..	12	23 0	..	..	600		
		9-inch ..	9	12 0	30	43	250	18	Sir W. Armstrong and Co. exhibited a 9-inch gun similar to the service 9-inch muzzle-loading piece.
		7-inch ..	7	6 10	14	22	115	8¼	
		64-pounder	6·3	64	6	8	64	4½	
	Breech-loaders.	7-inch ..	7	82	11	..	90	6¼	
		64-pounder	6·4	61	6	8	64	4¼	
Whitworth muzzle-loading 150-pr.			7	7 8	20	..	150		
French Service Breech-loaders.	Canon de 27 cm.		10·82	21 13	53	66·2	Steel shot 476 Cast-iron shell 310	..	French powder much weaker than British.
	do. 24 cm.		9·45	13 16	35·3	52·9	Steel shot 317 Cast-iron shell 220	..	
	do. 19 cm.		7·64	7 17·6	17·6	27·5	Steel shot 165 Cast-iron shell 115	..	
	do. 16 cm.		6·48	4 18·5	11·0	16·5	Steel shot 99 Cast-iron shell 695	..	
Krupp's Breech-loaders.	1,000-pounder........		14	50 0	110	130	Shot 1212 Shell 1080	17	
	9-inch		9	12 5	40	50	Shot 330 Shell 275		Could obtain no information respecting the 9-inch Swedish gun.
	6-inch		6	85	10	12	90		
Swedish muzzle-loading, 9-inch ..			9						

Evening Meeting.

Monday, March 16th, 1868.

MAJOR GENERAL THE HON. JAMES LINDSAY, Vice-President, in the Chair.

NAMES of MEMBERS who joined the Institution between the 2nd and 16th of March.

ANNUAL.

Hill, Sir William, K.C.S.I., Major-Gen. ret. Mad. Army. 1*l.*
Bluett, W. H. P. Gordon, Major 10th Regt.
Flower, Stephen, Lieut. 13th Light Infantry. 1*l.*

CARTRIDGES FOR BREECH-LOADING SMALL-ARMS, AND THE BEST FORM OF PROJECTILE.

A Paper prepared by CAPTAIN J. B. O'HEA, late 25th Regiment, and read by MAJOR-GENERAL BOILEAU, F.R.S.

AMONGST the inventions for which the past few years have been remarkable, breech-loading small arms take a prominent position in importance, ingenuity, and number; provisional protections or letters patent having been granted in this country during the year 1867 alone, for no fewer than ninety-eight descriptions of the arm. Great ability and mechanical skill have come forth in the production of this weapon; but in the perhaps more attractive pre-occupation of invention, the excitement of competition, or from some other unexplained cause, the cartridge—not a less essential element—appears in many instances to have been overlooked, and the projectile all but forgotten, or only noticed to be modified or altered out of all recognition to meet the necessities of the arm or powder charge. Some remarks, therefore, on "cartridges for breech-loading small arms, and on the best form of projectile," put forward

by one who is not so fortunate as to be himself an inventor, or so presumptuous as to question the inventions of others, may not be out of place just now at the Royal United Service Institution or altogether devoid of interest elsewhere.

Exception might be taken to the title of this paper. It may be considered by some who are trained to use the rifle, and interested in its improvement, that the subject of ammunition, apart from that of the arms for its use, affords but little opportunity for investigation or discussion. A few even may be inclined to question the influence which the form of projectile has on its range or penetration, or the near relationship of its weight to the calibre of the arm, and powder charge for its propulsion; should such objections be contemplated or advanced, I can but reply, that the ammunition is the primary invention in point of date and importance—that the cartridge contains the life of the arm, and gives to the weapon its distinguishing excellence for range, penetration, and in some measure for accuracy; the arm, however perfect, can only be remarkable as ingeniously-contrived time- and labour-saving pieces of machinery for carrying out that invention. For as the knowledge of the peculiar power of the composition now known as gunpowder led to the production of weapons for its utilization, and the discovery of fulminate of mercury, early in the present century, caused a material change in the arms of later years, so the invention of a cartridge containing its own means of ignition, has brought about an entire revolution in the construction of the military small arms of the present time. The cartridge therefore, now, as heretofore, claims precedence.

I hope that there are present this evening few, if any, who are not alive to the primary importance of judiciously weighted ammunition with a properly formed projectile. I see amongst those whom I have the honour to address, not a few who understand from experience what a secondary part the arm has to perform, when range, penetration, and in some cases accuracy, have to be obtained. Lest, however, there should be any one here who dissents from the divided subjects, "ammunition" without "weapons," I beg to say that I have a number of weapons, breech-loaders and repeaters, some taken from the valuable collection in this Institution, others of more recent invention not yet known to the public, but entrusted to me for exhibition this evening, the mechanism of which, as essential to the perfect understanding of the subject, I will, whilst reading my paper, so far as time will admit, endeavour to explain in connection with the more immediate object which I hope to illustrate, viz.: the question of ammunition; or at the close of the discussion, with the permission of the Chairman, I shall be prepared to afford to any one wishing for specific information with regard to any particular arm, such elucidation as a previous acquaintance with it will enable me to supply.

It is not my intention to trespass on you with a history of self-igniting ammunition from its ascertained origin; suffice it to say, that a cartridge containing its own ignition is by no means a recent discovery, for in 1831 Monsieur Robert made known his invention of such a cartridge, and in 1836 a Parisian named Lefaucheux, introduced

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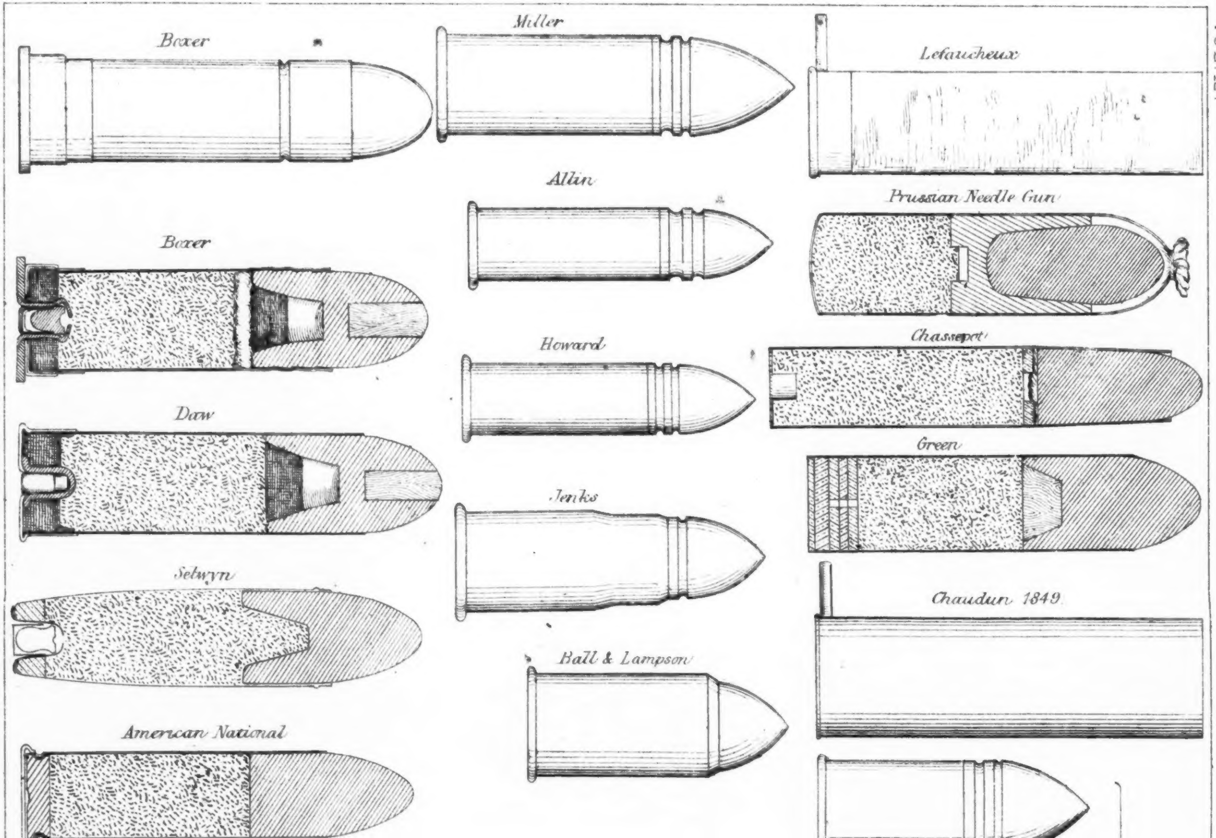
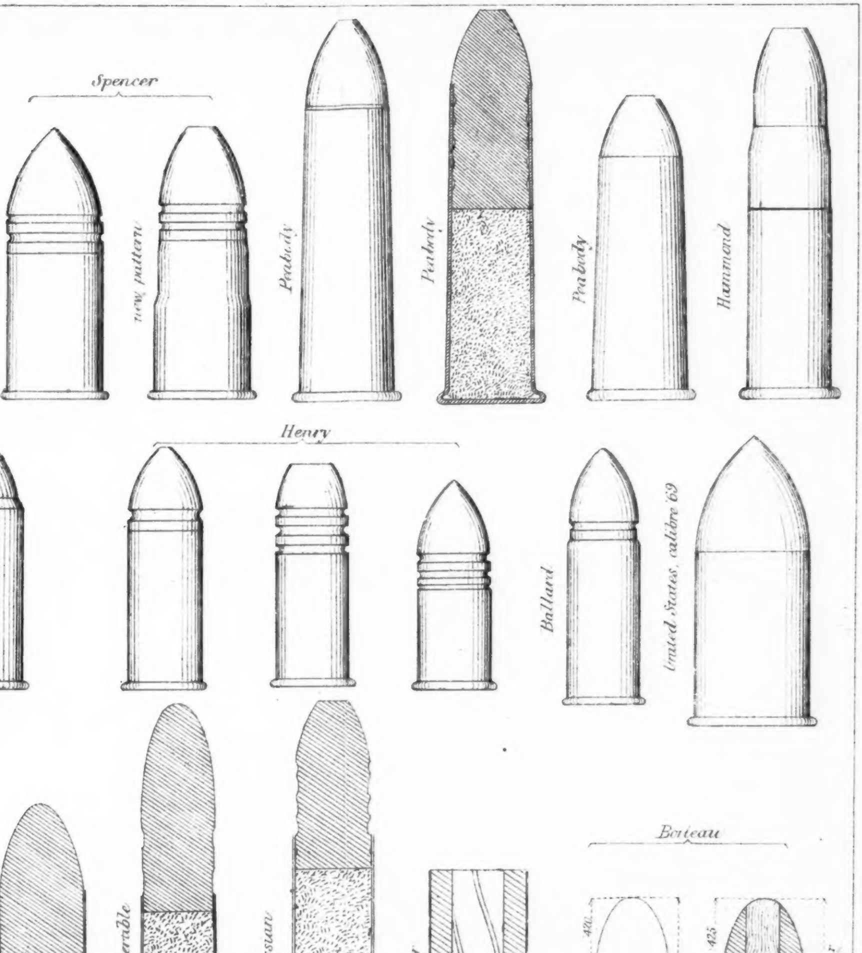


Boxer
Miller
Lefaucheux
Allin
Prussian Needle Gun
Boxer
Howard
Chassepot
Daw
Green
Jenks
Selwyn
Chaudun 1849
Ball & Lampson
American National


Spencer
new pattern
Peabody
Peabody
Peabody
Hammond
Henry
Ballard
United States, calibre '69
American convertible
Berdan, Russian
Mackintosh Tubular
for calibre '45
for calibre '50

J. Jobbins.

the pin-fire semi-metallic cartridge (see Plate VII), lately in general use with sporting arms, and which, together with Potet's anvil cartridge, has been the predecessor of the many improvements and modifications in central fire ammunition at present in general use with smooth bore and rifled arms. But it might be a fact worth noticing by those curious in the mutability of human opinion, that this very description of ammunition, now deemed an essential in the equipment of the armies of every nation of importance in the world, was from the fact of its carrying its own means of ignition, until very recently pronounced unsafe and consequently unsuitable for the use of troops by all European powers, with the exception of Prussia, which adopted the paper-cased cartridge, containing its own fulminate used with the lately famous needle-gun. This cartridge gives to that arm the only merit of the invention, namely, that whilst the form of the projectile remains unchanged, an excessive or over charge of powder cannot materially alter the range, or whilst the weight of bullet is not increased, give increased recoil; for the point of ignition being at the junction of the powder charge with the projectile, the latter receives the force of the inflamed powder less suddenly than if the cartridge was ignited at the base, and combustion being towards the breech, the great force of the propelling power is applied to a projectile in motion, from it. By this means recoil is greatly lessened, and the excessive force of an over-charge expended after the body being propelled, has left the bore.

The invention, some time since patented by Mr. W. Murphy, for applying the initial force of the powder charge to a projectile previously put, and actually in motion, through the bore, brings plainly before us the great value of the principle indicated by the Prussian needle-gun ammunition. Probably Herr Dreyse little dreamed of the value of a discovery which will, it is to be hoped, lead the way to a perfect method of loading at the breech, arms of the largest calibre; hydraulic power being adopted as a substitute for manual labour in the loading and working of the guns.

From the parent source, the self-igniting cartridge for breech-loading small arms has come to us in three distinct forms, viz., *the paper or skin-wrapped cartridge, the metallic-cased cartridge, and the bullet cartridge.*

The *first* named does not require, in the construction of the arm for its use, mechanism to extract or remove from the breech-chamber any portion of the cartridge-casing or wrapping which it is intended should be consumed with the powder or carried away in the discharge; but it throws on the weapon the entire duty of preventing gas escape breechwards, necessitating for this purpose, mechanism more or less complicated or perishable. The only exception to this rule, that I am aware of, is the paper-cased cartridge, lately invented by Mr. Green, of Blandford-street, Portman-square, which is so constructed as to divide with, if not relieve altogether, the arm of this duty.

The *second* named, the metallic-cased cartridge, while preventing gas-leakage breechwards, requires from the arm assistance in removing the metallic shell from the breech-chamber after each discharge. For this purpose at least one extra piece of mechanism is necessary

in the breech arrangements of every description of breech-loader I have been able to examine, with one exception, viz., the arm using the Selwyn cartridge, the metallic case of which is made, by the forcing of the rim into a groove by means of the explosion of the powder charge and the resistance to initial motion thus offered by the projectile, to cause its own retraction on the breech-block being opened.

The *third* description (the bullet-cartridge) is that in which the projectile is either made to contain its own means of propulsion, or is a metallic cylinder or powder-case containing the charge for propelling by means of a wooden wad, another cylinder of like form and weight, the powder-case, in its turn, becoming the projectile after discharging its contents; the ignition being by means of fulminate, placed in the wad.

Of the first class of ammunition (the paper cased or wrapped), there being but few varieties, I am unable to produce here to-night more than three specimens, namely, the Prussian needle gun-cartridge already referred to; the Chassepot for use with the French arm of that name; and the cartridge lately invented by Mr. Green, for use with his improved breech-loader.

The *first*, the *Prussian* (see Plate VII), which I shall call central-front-igniting, is a paper-wrapped cartridge, weighing 615 grains, and composed of four parts, viz., 1st. The projectile, solid, of lead, ogive-shaped, weighing 481 grains. 2nd. The papier-maché sabot, weighing, with the fulminate, which is placed in its base, 54 grains. The bullet, in calibre, much smaller than that of the arm, is imbedded in the front of this sabot, which fits the boring tightly, and is intended not only to bar gas escape round the projectile in its passage up the barrel, but to carry it on the rifling with its longer axis co-incident with the axis of the bore; thus imparting to it the after-rotation necessary for steadiness of flight. After leaving the barrel this sabot, from its lightness, recedes from the projectile, being removed by atmospheric pressure, and it is therefore a question how far, in consequence, it affects range and accuracy. 3rd. The powder charge, weighing 70 grains, the graining of which is very fine, intended to offer but slight resistance to the passage of the needle, and gives quicker combustion than powder of larger grain. 4th. The paper wrapping, weighing 10 grains. Total length about 2 and 10-100 inch. As can be perceived by an inspection of this cartridge in connection with the arm for its use, the provision against gas escape through the breech works is imperfect, as well as against misfire, caused by the deflection of the needle in passing through the powder charge, and consequent failure in striking the fulminate.

The *second* named, the Chassepot-cartridge (see Plate), is ignited in the centre of the base, and may almost be designated semi-metallic, as the priming, which is contained in a cap, like that generally used with the smallest class of nipple arms, being perforated to give passage to the spark, is protected by a metallic washer, placed inside the base of the powder-case, which latter is paper, rolled on a mandril, and pasted at the edges. The powder-charge being inserted, is pushed down gently to give rigidity to the cartridge—a marked peculiarity in this ammuni-

tion.* A wad, formed with an opening in the centre, is placed on the powder, into which opening the twisted end of the powder-case is inserted, and the projectile, wrapped in a paper jacket, pasted at the base only, is connected to the powder-case by a thread, passed round a groove, slightly behind the wad; finally the cartridge is greased. This cartridge weighs 485 grains, and consists of six parts, viz., the projectile of 383 grains, the powder charge of 80 grains, and the casing or wrapping, complete, consisting, with wad, washer, and fulminate, of four parts, 22 grains. Length of cartridge, 2 and 65-100 inches. On examining this ammunition in connection with the Chassepot rifle, it will be seen that it imposes on the latter the entire work of stopping gas-leakage through the breech, which is effected by the compression, under the action of the exploded powder, of a vulcanised caoutchouc washer, interposed between the front face of the breech-bolt and a shoulder or flange on the needle-guide, which is movable.

The *third* cartridge of this class of ammunition (see Plate) (Mr. Green's) is, as I before observed, constructed to check partly, if not altogether, gas escape breechwards. With this object, the inventor has ingeniously applied to his cartridge the principle indicated in the Chassepot gun, and in the well-known arm bearing his name, which fires by cap. In a cartridge case of the usual tough paper, gripping round the centre an Enfield bullet of 530 grains, a charge of powder weighing 70 grains is inserted. On this charge of powder is placed a wad, composed of three layers of cardboard, with a hole punched through the centre, in which hole, fulminate as powder, wrapped in paper, in the form of paste, or in the usual percussion cap is deposited; the first being preferable. An india-rubber wad, perforated through the centre with two small incisions in the form of a cross, is placed on this, and the powder-case is closed at the base by a single cardboard washer, over which paper is pasted, thus completing the cartridge.

I am informed by Mr. Green, the inventor, and by Mr. Cole, gun manufacturer, of Great Portland Street, who has modified the arm using this cartridge, that the india-rubber wad expanding under the pressure of the exploded powder-charge is a most effectual gas-check, the breech arrangements of the arm, after repeated trials, not having exhibited the slightest trace of gas escape from the cartridge, the wad, after each discharge, cleansing out the bore of any fouling. The total weight of this cartridge is 628 grains.†

In favour of the paper or skin-wrapped cartridge, there are generally advanced, facility of manufacture under most circumstances where powder, lead, and fulminate can be obtained, and consequent economy as well as certainty in supply; lightness in weight, and consequent ease in

* In the English school, packing or ramming the powder charge in any cartridge igniting at the base, is considered equivalent to loss of range.—J. O. H.

† I understand that the price of this ammunition will be about seventy shillings per thousand rounds; if packed in small tin cases, each case containing ten rounds, about one halfpenny per case extra.—J. O. H.

transport in large quantities, and to the individual soldier, in carriage; *against it*, liability to breakage, and deterioration in bulk or in the pouch owing to the defective protection afforded by paper wrapping or casing against deformity or damp, and consequent mis-fire, loss of range, and difficulty, if not failure, in loading; danger of ignition of fulminate from percussion otherwise applied than through the arm.*

With these remarks I shall take leave of this class of ammunition.

Of the *second* description the metallic cased cartridge, there is a greater variety, but all may be classed under the heads of simple and compound ammunition, the general divisions or sections of which, whether simple or compound, I assume to be four, viz., the shell, fulminate, powder-charge, and projectile, being entirely simple parts, or sections, in the one—some more or less compound in the other. Under one or other of these heads, come the various forms of the metallic cartridge at present known, whether with punched, folded, or, shall I say, built-up cases; of copper, brass, or other metallic substance; rim igniting, central fire, or convertible to either system, with solid, hollow, or compound projectiles, many possessing some peculiarity or merit to distinguish them, which, in the space of this paper, it would be impossible to notice at any length, without infringing the rules of this Institution. Having no wish, therefore, to make distinction, I am compelled to select for description some particular cartridges more or less familiar to the services, as well as to civilian riflemen, and a few of late invention, foreign as well as British, not so generally known.

1st. According to date of invention, comes the rim-fire copper-case cartridge of the United States.

2nd. The British service cartridge known as the Boxer.

3rd. That more recently patented by Mr. Daw, of Threadneedle Street.

4th. The Selwyn cartridge before referred to; the invention of Captain Selwyn, R.N.

5th. The American copper-cased cartridges, the one known as the National, for use with the national arm: the other called, I believe, the Empire cartridge, both of which are convertible to rim or central fire.

6th. The Berdan Russian cartridge, for use with the improved Berdan arm, the right to manufacture which in Europe, has just been purchased by the Russian Government.

Although, I believe, the punched or drawn metallic-cased cartridge is not, strictly speaking, of Transatlantic origin, (I have here a punched, or drawn, brass shot cartridge case, pin fire, manufactured in Paris some time prior to 1849 (see Plate), yet ammunition of this description was first largely adopted for military weapons by the Federal authorities during the late civil war in America, and was the parent of the many beautiful inventions in breech-loading small-arms every day claiming attention. There cannot, I think, be a doubt but that to the adoption of this cartridge, and the weapons it called forth, may, in a good

* It has been satisfactorilly ascertained by experiment that ammunition in the form of paper-cased cartridges, even containing fulminate when made up in bulk, will not explode en masse on the ignition of one or more units.—J. O. H.

measure, be attributed the closing of the great civil war of modern times.

As far back as April, 1860, simple metallic-cased rim-igniting ammunition was manufactured at Springfield, Massachusetts, for Spencer's Repeating Rifle, since modified into a single loading, as well as repeating arm; and other cartridges of this description had previously been made elsewhere in the United States.* The case is of copper, punched or drawn, weighing with fulminate 75 grains. This cartridge having to be carried in a magazine limited in extent, is short for an arm of 50 calibre, measuring but 1·70 inch.

The Spencer cartridge (see Plate), weighs 480 grains, carries a leaden projectile of 360 grains, and a powder charge of about 45 grains, which the excess of fulminate in the rim is supposed to make equal to 50 grains. Although this weight of ammunition may not exactly succeed in making a long range score at Wimbledon, at ranges within 450 yards, even with the original pattern arm, in the hands of troops more or less practised, it did splendid service for the Federal cause, as the record of Colonel Wilder's famous corps of mounted infantry in the army of the Cumberland bears testimony.

Spencer's improved ammunition and arm have been recommended for adoption in the United States' cavalry by the Board on Small Arms, of which General Hancock was President.

There are here other descriptions of American rim-igniting cartridges for single loading arms, of more recent invention, containing charges varying from 55 to 70 grains of powder to propel from 380 to 450 grains of lead, the cases of which are more or less coned from base to projectile, in order to facilitate extraction and admit of an average charge of powder being contained in a cartridge of medium length. Such are the Peabody (see Plate), the Joslyn, the Hammond (see Plate), and the Remington (French and Danish).

The second named, the Boxer cartridge (see Plate), for which distinct patents were obtained in January and October, 1866, is too generally known to call for an extended or detailed description. It is a compound cartridge, central fire, two and a half inches in length, weighing about 700 grains, contains 70 grains of powder, to propel a projectile composed of lead, wood, and clay, weighing 480 grains. The case is built up, being composed (including the percussion cap) of three descriptions of metal, and of nine pieces; namely, the cap-chamber and the anvil (which are brass), the cap for fulminate (which is copper), the base disc, or washer, which is iron, and in consequence less likely to fracture or give way than brass, when force has to be used in its extraction, the base metal cup, the cartridge body or coil, with the paper wrapping, a second metal base cup or coil, an additional base coil, the latter intended to regulate the relative resistance in expansion of the cups and coils and prevent the cutting through of the body of the case at the time of firing; lastly, the wad, cup-shaped, composed of papier-maché, lead and tin, or an alloy of lead and antimony the con-

* The cartridge for Ball's carbine (the first arm invented, which combines the power of repeating and single loading,) is of this short description, weighing but 475 grains.—J. O. H.

densing of which securely fastens together the base disc, cap-chamber, and body of cartridge. There is also a space between the powder and the projectile, containing wool or cotton wadding, which lessens the initial shock of the powder-charge on the projectile, and consequently somewhat diminishes recoil. This cartridge is used in a breech-chamber considerably larger than its diameter, by which it is intended to obviate all difficulty in loading even when the cartridge is in a deformed state; and the case being uncoiled by the explosion, instead of being expanded, is supposed to be not only a preventative to gas escape breechwards, but also a security against fracture or splitting of the metal. The arrangement of the anvil with shoulders or projections, which prevent it from passing into the cap, and keep the point of the anvil at a safe distance from the fulminate, is new, and intended to obviate all danger of ignition when the cartridge is dropped accidentally, or subjected to any other blow than through the striker of the fire-arm, or that which indents the back of the cap.

It not being my province or intention to offer an opinion on particular inventions or modifications, I shall only state that of the nine arms chosen by the Special Commission to compete for the rewards offered by the Secretary of State for War for the best breech-loading small-arm fulfilling certain conditions, six used cartridges on the Boxer coil principle.

The next cartridge (see Plate), (the property of Mr. Daw), which, in consequence of his system of casing made known in 1866, I have named *third*, although the remainder of the invention was, I believe patented as far back as 1851, is also compound, and contains peculiarities of a marked and ingenious description. It weighs 660 grains, carries 70 grains of powder, to propel a projectile, expanding by plug, weighing 480 grains. The cartridge case, which weighs only 105 grains, with the exception of the usual copper primer and papier-maché wad, is brass, and composed of six pieces, viz., the percussion cap, anvil, cap-chamber, base of shell, wad, and body. The latter is composed of a little over one fold of excessively slight and tough metal, which being united by solder, renders the case perfectly gas and water-tight, dispensing altogether with paper or linen wrapping. The shortness combined with a slight shrinking of this case when relieved from gas pressure and extreme heat after discharge, renders the extraction of the shell most certain and easy. I will only add in proof of the perfect expansion of Mr. Daw's cartridge, that when using it with an indifferently chambered Wantzel arm some time ago, I saw, on a freely extracted shell, the model of a flaw in the breech chamber of the arm, as if taken with wax.

The foregoing metallic cartridges, require in the arms with which they are used, extra mechanism for the retraction of the metallic shell.

The *fourth* is peculiar in breech-loading ammunition, not only as a clever contrivance to suit a particular arm, and a departure from the principle and fashion of other cartridges with punched or folded metallic cases, but as calculated to simplify the construction, and consequently cheapen the manufacture of arms for its use. It is a special cartridge (see Plate), the invention of Captain Selwyn, R.N., to be used

with a breech-loader, also his invention, and is an exception to all other ammunition I have seen, in the form of its casing, and the means employed for extracting the shell after firing. The one ingeniously reproduces in a cartridge, the principle, indicated in the well-known and once-prized patent breech, of igniting the powder charge as nearly as possible at the apex of a conical shaped chamber; the other renders unnecessary in the weapon using it, springs or other pieces of mechanism for extracting the shell, which in this case is removed from the barrel after discharge by simply opening the breech block, and slightly canting the arm: moreover, by converting this block into a patent breech, additional length of rifled bore is obtained without increased length or weight of barrel. The case of stamped or drawn brass or copper is in form spheroido-conical, the cone being slightly truncated by returning or cutting off a small portion of the apex. Here the cap-chamber, containing the percussion cap and anvil is inserted, being secured by a wad pressed or choked inside. When charged with 75 grains of powder, and a projectile of 480 grains, either for half-inch or regulation calibre, the cartridge is complete.

To load the arm, the cartridge is placed in the breech block, which opens over on the barrel, as in the Mont Storm, and is chambered to receive three parts of the length of casing. On returning the block to its seat, the projectile and that portion of the cartridge shell holding it, is inserted into the breech end of the barrel, round which there is a groove or depression into which the shell is expanded by the explosion of the powder charge and resistance to initial motion offered by the projectile, thus sealing the breech against gas escape, and compelling its extraction from the breech-chamber, as well as release from the barrel by the act of throwing open the block.

The length of this cartridge is two and a half inches. The total weight 670 grains. The cartridge is ignited by a blow transmitted through the bolt, which secures the breech block.

The *fifth* description is an American modification of the metallic-cased rim-igniting cartridge, converting it to central fire in two different ways; in the one (see Plate), by the insertion in the case of a triforked anvil, the flank prongs of which being fixed in the rim, secure the anvil in the shell, the centre prong (which is inserted in the percussion cap, placed on the surface at the base) serving to ignite the fulminate: in the other by the insertion inside the shell of a metal bar across the base, which is held in its place by pinching the case at the rim into shallow grooves in the ends of it, fulminate in the form of paste, or folded in paper, having previously been deposited on the surface of the shell beneath the centre of the bar or anvil, which is slightly concave in the middle to prevent contact with the fulminate by accidental concussion, or otherwise than by indentation from the outside of the surface of the case by a blow from the striker. This latter is known in the United States as the Modified National Cartridge. The total weight of the former cartridge is 650 grains, carrying 70 grains of powder to propel 480 grains of lead, the projectile for ·45 calibre being coated over with compound lubricant. The length is 3 inches. The total weight of cartridge, and weight of powder charge and pro-

jectile being the same in the latter for ·50 calibre. The length being 2 inches and thirty-one hundredths.

The *sixth* is the brass-cased cartridge (see Plate), invented by Colonel Berdan, of the United States Army, the well-known organizer and commander of the corps known during the civil war in America as Berdan's Sharpshooters. As before stated, the right to manufacture this cartridge in Europe, has lately been purchased by the Russian Government,* and I selected it from others, also of much merit, in consequence of some interesting experiments connected with it, which have lately taken place in the United States, before the Russian Commission, of which Colonel Gorloff, of the Russian Ordnance Department was President, and also of the information emanating from these experiments with reference to the relative weight of powder and projectile for certain calibres. Determining as a first condition, the weight of firelock the soldier can carry without detriment to his efficiency, to be about 9 lbs. 4 oz. exclusive of bayonet, 10,000 rounds of this ammunition were fired from the Berdan arm of this weight in a series of experiments daily, extending over a week. One of the chief objects of the trial was to ascertain the relative weight of powder and projectile made up in cartridges, giving the flattest average of trajectory at ranges within 750 yards, and consequently the longest dangerous distances or spaces, the term given in the American service to what is known in our school as the first infantry catch and graze of the trajectory.

From a barrel of 3 feet in length, of ·45-inch calibre, rifled with six shallow grooves equal the lands in width, having one turn in 2 feet, the following results were obtained.

The Berdan central primed cartridge, with 77 grains of powder, propelled 415 grains of slugged lead, with the initial velocity of 1,600 feet per second, trajectory $5\frac{1}{2}$ inches in 200 paces; dangerous space, 400 paces; elevation, 10 minutes, 200 paces; mean deviation, $2\frac{2}{10}$ inch; 200 consecutive shots, 200 paces, the range up to 200 paces being protected from the influence of side wind.

For the above information I am indebted to the treasurer of the Union Metallic Cartridge Company, Bridgeport, Connecticut, who assisted in conducting these experiments. The total weight of this cartridge is 685 grains. The case is composed of three pieces, viz., the drawn or stamped shell; the re-inforcing ring or saucer, which guards against gas leakage through the base, and the percussion cap, all of brass. In the centre of the head of the case is a cavity, of size sufficient to contain a little cone-shaped anvil, which is drawn up from the metal itself at the bottom of this cavity. It is counter sunk, so far that a little basin-shaped percussion cap on being driven in, wedges fast, flush, or level with the base. The cartridge-case can be reloaded repeatedly, the exploded cap shell being picked off, a fresh one put on, and after inserting the powder charge, a bullet set in with a small

* It had been previously commended by the New York Board on Arms, Ammunition, &c., of which General Palmer, Commissary General of Ordnance, was President, as possessing peculiar merits.—J. O. H.

starter, like those used for muzzle-loading ammunition. I regret not having received in time to exhibit here this evening, specimens of the ammunition for the Roberts arm, lately recommended for adoption by the board of officers, which re-assembled at New York State Arsenal by special order, dated June last, to further test the Allin, the Berdan, the Roberts, and other methods of converting the muzzle-loading Springfield musket into a breech-loading arm.

Additional to the primary condition requiring that in all arms submitted for trial the barrel should be of ·58 calibre, or if reinforced by the insertion of a tube, of ·50 calibre, it was further required by the Board that the cartridge cases should be of brass with "central fire," the projectiles of unalloyed lead, and to weigh 480 grains for guns of ·58 calibre, and ·450 grains for calibre ·50; the powder charge to be the United States standard of 70 grains, Orange rifle powder, F.G.*

I am disappointed also in not having received specimens of the Fogarty ammunition for use with the Fogarty arm, which is exceptional, inasmuch as a central fire cartridge is used in a magazine arm.

I shall close my remarks on this class of ammunition by observing, that in *favour of* the metallic-cased cartridge, there is generally advanced, security from deterioration by time when not lubricated with material containing acids, and from injury by damp, even if immersed in water, or from rough usage in transport; prevention of gas escape breechwards by expansion of the case, and consequent certainty of initial force of powder charge being applied to the projectile, which is held or gripped by the shell. To these may be added a saving to the arm using it from strain, overheating, clogging, or sticking of the working parts; also from accumulation of fouling where combustion takes place, the fouling being removed with the retracted shell after each discharge; facility of reloading repeatedly the extracted shell (with few exceptions), and consequently a saving in the cost of manufacture; lastly in "central fire" cartridges, protection from ignition otherwise than by percussion applied through the arm. *Against it*, the primary expense of manufacture, particularly in cartridges composed of many parts; additional weight caused by the metallic case, for transport in bulk, and for the individual soldier to carry; the necessity in almost every instance for extra mechanism in the arm, using it, for extraction of shell; should extraction become difficult, or fail by sticking or fixing of the case, or fracture of the head or disc, a temporary disabling of the arm using it, unless it be encumbered with a ramrod; in some instances the waste of expensively manufactured shells which cannot be re-charged without the aid of mechanical skill or machinery; deterioration in storing, when lubricated with material

* The third regulation or condition of the Board is curious, viz., that the arms be fired such number of times as the Board may deem necessary with defective cartridges (that is, with cartridges filed or cut three parts round the base of the shell), to test the stability of the breech arrangements by gas leakage, and the immunity from danger of the person firing, should the cartridge burst at the head or in the chamber, from excess of fulminate, defective casing, or other cause.—J. O. H.

containing acids; and fouling or leading of the barrel, when proper lubricant is not used.

The *bullet cartridge* is represented here to-night by the invention of Mr. Mackintosh. It has been already ably noticed in a paper read by Captain Selwyn, R.N., at this Institution, on the 21st January, 1867, and its merits fully explained by the inventor, in the discussion which followed. It weighs about 600 grains.

I now turn to the projectile which, although, the last portion of the cartridge to be noticed, is by no means the least, if it is not the most important, of its component parts.

The fashioning, balancing, and weighting of missiles, with reference to the power to propel and purpose for use, have at all times, and with all people using warlike weapons other than fire-arms, been objects of particular care and study; so the form, weighting, with reference to propelling force (the powder charge) and correct placing of centre of gravity with regard to figure at least, as correctly as it may be possible to place it in a projectile of soft metal, ought to be primary objects of investigation now as heretofore.

Indeed, it is the conviction of those whose ability and practical knowledge of the subject make such opinion unquestionable, that until these points in the projectile have been thoroughly investigated and definitely settled for the arm of defined weight and calibre, it is waste of time, money, and skill, testing machinery, no matter how ingeniously contrived, for rapid breech-loading and repeating fire.

The principles which Captain Norton and General Jacob so zealously advocated, still hold good, and must now be acknowledged correct by all who study the subject of small-arms ammunition.

The projectile, like the cartridge, may be classified under the heads of simple and compound, both as regards form and component materials—the one in figure or substance being simple, the other compound.

Under the first head come spherical, conical or picket, cylindrical, and tubular, the last being the only form of this class calling for remark. Under the last, come the ogive and cylindro-conoidal, the latter best known, most highly favoured, and of all forms most generally adopted in its few varieties of length of cylinder to length of projectile, and figure of cone. To this form of projectile, being the earlier invented, and the most generally used, I shall first ask your attention.

To Major-General Boileau (whose scientific knowledge and practical experience make him a most reliable authority) I am much indebted for information regarding this form of projectile. He is of opinion that the cylindro-conoidal form is the best for all calibres of rifled small-arms, a small length of the cylinder only being necessary to hold a leaden projectile in the rifling, increased length of cylinder in the bullet requiring increased pitch of rifling in the barrel to steady its after-flight; but under any circumstances, the proportion of length to diameter uniformly diminishes as calibres increase.

In the larger calibres, it becomes necessary to have fore and base cavities, for the purpose of retaining length of projectile without extra weight, these calibres containing wood, baked clay, or other compara-

tively light substances. The cavity at the base need not exceed in depth one-quarter of the length of projectile, and should be coned to suit the form of front of bullet.

The impossibility of defining the exact position of the centre of gravity with regard to figure in projectiles composed of soft metal must be evident to all, as in every case where ignition of powder-charge takes place at the base, there is an alteration in the form of projectile, caused by the upsetting of the metal on the projectile being started from a state of rest by the sudden pressure of the ignited powder-charge, and the inverse resistance of the column of air in the barrel as well as the pressure of grooving on the cylindrical portion of the projectile. It is more than questionable how far placing the centre of gravity well forward, or in front of the centre of figure, as was till lately considered necessary in projectiles for high trajectories, and was one of the objects of the deep base cavity, affects accuracy and range when slow pitch of rifling is used.

From the fact that lead when rubbed on a substance of any solidity leaves a deposit, it must be evident that the frictional surface of a leaden projectile should be covered either with paper, linen, or lubricant of a peculiar compound, to save the bore from the fouling, which contact and friction of lead with the barrel are certain to produce. Paper and linen-wrapping are most suitable to bullets taking the rifling by expansion, when the projectile is of somewhat smaller calibre than the bore.

For projectiles of larger calibre forced into the rifling, a lubricant is necessary, the cylindrical portion being canelured to hold it, as well as to cause the projectile to take the rifling more easily. The weight of the projectile with reference to the powder-charge for its propulsion, as well as its form, is a matter upon which, at the present time, American experiments are throwing much light.

With regard to the experiments with the Berdan cartridge and arm, up to medium ranges, viz., from six to seven hundred yards, a very flat trajectory was obtained by comparatively large powder charges, giving increased initial velocity to a rather light projectile, that is from 77 grains to 80 grains of powder with from 415 grains to 420 grains of solid lead, fired from a barrel of ·45-inch calibre, with a rather sharp twist of rifling and with shallow grooves.

The tubular bullet, referred to under the head of "simple projectile," a recent British invention, the property of Mr. Macintosh, is exceptional, and though as yet not widely known, will no doubt be a valuable addition to the forms of projectiles at present used, particularly for larger calibres of small arms, if it does not cause an entire revolution in the bullet of the future. The principle, but partly developed in the bullet used in the Boxer ammunition, is more perfectly brought out in this projectile by placing the weight near the surface of a cylinder, on the principle of the fly-wheel, in order to keep up, after it has passed out of the barrel, the spin imparted to the bullet by the rifling. Moreover Mr. Macintosh, by firing a tube rifled with considerably raised lands, through which, during flight, a column of air is passing, as a male-screw, not alone obtains dimin-

ished atmospheric resistance to the passage of the projectile, but secures atmospheric assistance in keeping up rotation, and doing away, to a great extent, with the atmospheric vacuum at the rear, which is an incurable defect in the solid bullet, and one cause of the swaying or dropping of the projectile out of the line of flight.

I should wish here to express my thanks to Messrs. Reed and Son, the well-known ordnance and small-arm manufacturers, of Boston, United States, for the information I have received from them on the subject of American arms and ammunition.

I shall now close the paper which I have written with diffidence in my ability to do the *subject of ammunition* and *the best form of projectile* anything like justice, by expressing a hope, that whatever information it may fail to impart, will be evoked in the discussion on it from the greater ability and experience of the assembly I have the honour to address.

Major-General BOILEAU, F.R.S.: I should wish to say a few words on the subject of this very interesting paper, not that there is much that can be said by way of result or experiment, for, as regards cartridges, I believe very few experiments have been made. But it is satisfactory to know that while foreign Governments have appointed boards to report upon forms of projectiles and cartridges, in respect of metallic and paper cases, and other requirements, which have been so ably pointed out by Captain O'Hea, we have not in this country been idle. Some time ago when the Government issued advertisements for the submission of rifles, they fixed the bore at 0·451 for the rifle which was to be submitted for competition. They also laid it down as a condition that the bullet should weigh 480 grains, and the powder charge should not be less than 70 grains. Most people have considered that these were standard and fixed elements which were not to be departed from, consequently we find that, in most of the trials which have been made with cartridges with metal cases, and others, the standard has been 480 grains for the bullet and 70 grains for the powder charge. I have myself given a good deal of attention to the best form of projectile, and have made, as far as I could, experiments with regard to their different ranges. The result of my own experience was, that for a bullet of 480 grains, a form like that of the bullet in my hand (see plate) was particularly applicable. The lead is not pure, because I approve of somewhat hardening the bullets; it makes them keep their form better, and it gives them greater power of penetration. I had the opportunity of once trying those bullets before the Victoria rifle corps range (to which *corps* I belonged) was abolished. The workmen were employed removing the range, and I had only a short time for the experiment. Out of four shots which were fired, the first was a trial shot, three hit the bull's eye at 300 yards, and went into so small a space that they might all be covered by the hand. That form of bullet was what I intended to introduce in my own experiments as the bullet for the future. For the small-bore calibre cartridges I made a bullet of much the same form, but without wooden fore-peg (see plate). These were supplied in large quantities to Mr. Daw, who was experimenting with a bullet of his own at Kilburn, which did not make good practice. He used a bullet lubricated with wax, and the result was decidedly bad. I supplied him with 400 of these bullets, in paper greased, and he wrote to me that the performance of the same rifle, with the same charge of powder and my bullets was marvellous, he hardly had a shot that did not hit the bull's eye; so that for cartridges carrying 480 grain bullets, those two appear to me as good as can be used. But the question of weight has, I have to-day ascertained, experienced some change. On examining the Boxer ½ inch cartridge—a specimen of which Colonel Boxer was kind enough to send to the Institution—I weighed the bullet, the last adopted, and I found it only weighed 365 grains; now that is a very large diminution in weight from 480 grains. It occurred to me to investigate the circumstances under which the intelligent and experienced officer, who produced this cartridge, has adopted such a light bullet. The ground

for the change, which has offered itself to my mind is that which is connected with the resistance offered by the air to the projectile. The resistance is known to vary, as the surface of the right section of the bullet, or, in any other terms, to vary, as the square of the diameter of the bullet, directly, and inversely as the weight. The new Enfield rifle, when converted into a breech-loader, was charged with a bullet of 480 grains, and very good practice was made with it. Here are some bullets for the Enfield rifle, they are made by myself, but they are very nearly the same as the Boxer bullet. If we take, then, the proportions of the squares of the diameters of different rifles, take, for instance, the Enfield rifle as ·577, and the rifle which is presumed to be adopted, *i.e.*, the half-inch or small-bore as ·500, we find that, adopting 480 grains as the standard for the Enfield rifle, 360 grains comes out as the proportion for the half-inch, and that is within 5 grains of the weight that Colonel Boxer has adopted, so that the half-inch cartridge with a 365 grain bullet would produce the same effects, under the same circumstances, as the old Enfield bullet would produce with a 480 grain bullet. This appears to me quite a sufficient justification for its use, provided that after experiment it is found to have the same powers of penetration, and the same powers of retention of form, as the old Enfield bullet has. The lead appears to me to be rather soft, and I would suggest that in the bullets of the future a hardening material, either an alloy of lead and tin, or lead and antimony, should be used.

The CHAIRMAN: What is the diameter of the bullet?

Major-General BOILEAU: The diameter of this bullet of Colonel Boxer's is 0·495, that is, it is $\frac{1}{5000}$ of an inch less than the calibre of the gun itself. But as before leaving the gun the bullet is supposed to be set up in the rifling, so as to fill up the bore, I have taken the bore of the rifles instead of the diameters of the bullets in making the comparison. The length of the bullet is 1·08 inches, that is, it is rather more than twice its diameter. I have no doubt that before adopting it, experiments were made, and that this is the result of the trial. The bullet appears to be solid enough. From a section, of which we have a specimen in the Museum, I find that there is a fore cavity as well as a base cavity. The original bullet was made with a longer base cavity, which is not a good form. I have experimented largely with bullets having a long base cavity, and they were some of the worst that I have ever tried. They look very well, but they are positively worthless; when fired from the rifle we did not know where they went, they seemed to split all to pieces. For a good practical reason the original form of the bullet has been altered. There is a diaphragm of lead in this second pattern, and there is a very long base cavity, $\frac{6}{10}$ of an inch in length, into which a clay peg is inserted. There is also a fore cavity in front of the bullet, it is covered over with a film of lead, though it appears to be solid. This improved bullet is, therefore, a deceitful fellow, for in striking, the front film would be broken down, and the head of the bullet would spread out, adding greatly to its damaging effect, which I look upon as an important change; if the bullet will hold its form, and it is found on experiment to succeed, I consider that to be a very great step gained. With regard to the powder charge, of course if the same charge of powder, 70 grains, is used with the 360 grain bullet, as was used with the 480 grain bullet, it will give the additional advantage of greater velocity. I must say that I look forward with much interest, but not without some misgiving, as to the success of this bullet. With regard to the cartridge case, without wishing to make any comparisons, my own predilection is in favour of a very thin metallic case, but not the coil case. My experience on testing that description of case is, that it is perfect; this one, a brass foil round case, which has been fired, has come out of the rifle as smooth as a piece of glass. I cannot say that I have found it practicable to reload them, but I have never had one misfire, neither have I seen one of them break. With reference to the question of fracture and danger from the splitting of the cases, I observe in the report which Captain O'Hea was kind enough to lend me, that in some experiments lately made in Albany, New York State, they split the cartridge case nearly from end to end before firing, and in some cases they filed the head almost off, but neither in one case nor the other was the shooting at all impaired, nor was there any escape of gas from the breech; therefore, I think we are taking more pains than is necessary in the

construction of our cartridge cases. If they are made water-tight, and sufficiently strong at the breech to prevent the escape of gas, that appears to me to be all that is necessary, and we shall be able to have a cartridge as good as we require at a moderate expense. Other speakers are, no doubt, anxious to address the meeting, but I am desirous of laying before you the result of my experiments with bullets in the half-inch small bore breech-loading rifle. The Boxer half-inch cartridge promises very well, and we need not be afraid of being behind other countries whenever the tug of war may come.

Mr. DAW: Captain O'Hea has been kind enough to bring forward a cartridge bearing my name. He puts it in order as second to the Boxer cartridge. Although I am interested in all that Captain O'Hea has laid before us to-night, and I may say it is interesting to all who study cartridges, I must say that I claim priority to Colonel Boxer; I made these cartridges upon which his cartridge is based four years or more before he attempted it.

The CHAIRMAN: We have nothing here to do with priority of invention.

Mr. DAW: With regard to lightness I would say that the cartridge shown here to-night, I have no hesitation in saying, can be made by the Government very much cheaper than their present one. That is a very important matter. The $2\frac{1}{4}$ coil, which Colonel Boxer's was at the time I sent in my cartridges for competition, was found to have certain defects, and now, that he has copied mine of $1\frac{1}{4}$, it is found to work better. I was the first to produce a $1\frac{1}{4}$ coil, and whatever claim is made for the Boxer I say it is based upon my principle, which was patented before he made the $1\frac{1}{4}$ coil. With regard to the bullet which General Boileau has alluded to, I can bear testimony to the excellence of the bullets he has prepared with greased paper wrappers. I have been abroad and travelled through Europe, and have witnessed different experiments by different Governments, and I can say that the bullets that were made with a greased-paper wrapper were excellent, and that they surpassed any bullets that came into competition with them, they gave a lower trajectory. I am sure when the question of bullets is gone into, the greased-paper wrapped bullet will be found better than the bullet with lubrication.

Captain JASPER SELWYN, R.N.: This is a subject in which I have taken much interest, I will, therefore, take a piece of chalk and illustrate what I have to say on the black board. I represent the cartridge case by C, the bullet by B, and the powder by P. I like to assume the extreme weight of the cartridge case rather than the lowest weight, for I have found that the cartridge case is quite up to 120 grains, therefore I put in all cases the cartridge case at 120 grains. I put the bullet at its varying weights of 530, 480, 320 grains; then for the tubular bullet I take off the cartridge case altogether, and put the bullet at 520 grains. Next I put the powder in all cases at 70 grains:—

C	120	120	120	
B	530	480	320	520
P	70	70	70	70
	720	670	510	590

Then 720 grains will be the weight of the first cartridge, 670 grains the weight of the second, 510 grains the weight of the third, and 590 grains the weight of the fourth. I will now put the bullet and powder alone, supposing we can do away with the cartridge case:—

B	530	480	320	520
P	70	70	70	70
	600	550	390	590

The first would weigh 600 grains, the second 550 grains, the third 390 grains, the fourth 590 grains. With the first I should get 70 cartridges, supposing my ammunition to be equal to 6 lbs.; the second would give me 76 cartridges; the third 108 cartridges; and the fourth I have not taken out—you can easily see how

it will vary. We have abandoned the bell cup and anvil; therefore, it is not necessary to calculate for that. Now, for a second I will amuse you with an American story before I begin; it will illustrate very strongly the point which has been brought before us. An American in my presence was speaking of the new gun which the Emperor of the French has had brought to his notice, which will fire I do not know how many shots a minute, and requires only two men to attend to it. The American's remark was very pertinent indeed to the whole subject: "I want to know who is going to carry the lead." You can easily see that my object in this instance has been to show you that the weight of the projectile can be advantageously diminished, for, even admitting that the cartridge case is absent in the last case, you cannot make much change in the powder charge; but you can make a very notable change, as Colonel Boxer has shown us, in the weight of the bullet. Then you have the enormous value to the breech-loading gun, which is supposed to fire 20 shots in a minute, of the 320 grain bullet, giving 390 grains with the powder. Everybody knows that reserves can be brought up, and are brought up; but everybody knows that reserves, I mean reserves of ammunition, are not always in the right place when wanted. I have to recognize most gratefully the very kind notice which Captain O'Hea has been pleased to take of my gun and cartridge, which some of those present will appreciate or depreciate for themselves. All I have to say is, that the only cause why the gun was not brought forward at Woolwich, and for which I have a certificate, was that the cartridges were made too short, and they failed of their effect. The workmen beat up the gauge to conceal a defect in the workmanship. I have fired hundreds of rounds with it, and I say it is the true weapon for the soldier or sailor, on the score of simplicity, and of not being liable to derangement. I would draw your attention to this—that the Americans, however much they may have been behind us in some questions, are yet attacking the question from a scientific point of view. They do not make the mistake of first looking at a number of breech-loading guns, seeing how pretty they are, how well got up they are, what they weigh, and what they do not weigh. But they go straight at the projectile and its trajectory; for, as Captain O'Hea has very truly remarked, the projectile is *the* whole basis of the question. If you cannot tell what weight of projectile, or what form of projectile you are going to fire, it is utterly impossible for me to tell you what powder charge you shall fire it with; consequently, out of what arm you shall fire it. Projectiles vary so enormously that in the same gun I will engage you shall not get the same shooting with two bullets out of a hundred. Mr. Whitworth found that by elongating an ordinary Enfield bullet and increasing its weight the accuracy was brought up to that of the small bore. Mr. Macintosh, and those who have proposed his tubular projectile, found—and this is utterly independent of testimony from Mr. Macintosh himself—that, with the smooth-bore musket, the elevation of the sight, necessary to carry a bullet from the ordinary Enfield rifle 900 yards, was sufficient to carry with increased accuracy the tubular projectile 2,000 yards. That is the result of following a true scientific principle. Where you can reduce the resistance of the atmosphere, you achieve much more than by anything you can do in the barrel of the gun; for while the barrel of the gun acts only during the fraction of the second in which the bullet is passing along the 30 or 40 inches of its length, the atmosphere is acting throughout the whole flight. If you can abstract resistance from the front, or can diminish the vacuum behind, it is clear that the trajectory of the projectile must be flatter; that the causes of disturbance will be less; and that, if properly brought forward and closely experimented upon, it is calculated to effect a revolution in our ideas; not alone respecting the different descriptions of fire-arms, but respecting that old and much vexed question whether it is necessary to rifle barrels at all either in large guns or in small arms. We have long ago known that for all possible purposes, whether of sport or war, it is necessary to suit the projectile to the object, and not to change the arm because you want to attain a special object. A special projectile has this great value, that it does the work for which it is meant, out of a gun which is equally capable of doing any other special work when it is required. With regard to those systems which have been noticed this evening, in which india-rubber is adopted as a means of preventing the escape of gas, I have only to say

that, in consequence of several and long-continued telegraphic researches, I have been led to make experiments upon india-rubber and vulcanite. I found that vulcanized rubber, which is the most lasting form, decays invariably in the course of a very few years. We may see that always in our ordinary india-rubber bands for letters; by the oxidization of the sulphur which is used to cure it, the india-rubber becomes rotten. Therefore, india-rubber is not a reliable thing to be stored up in magazines. You may find vulcanized india-rubber which may give you good results as a gas closure in England, for a space extending over a few months, but which will give you very unreliable and bad results after it has been stored in India for a year, or less than that. Therefore, I eschew *in limine* all substances which are liable to quick decay. I do not say that all substances are not liable to slow decay. The tubular system which has been adverted to by Captain O'Hea is not a recent invention. He has been a little mistaken there. It has slept in consequence of the doubts and pre-occupations of its inventor. It has been some twelve years before the public. When I tried to get it experimented upon by the higher authorities, I was answered that so many systems had been tried that this was not worth trying. I think that is scarcely an argument, and I hope still to see the thing carried out. The advantage of the tubular bullet is even more than that to which I have referred. We know now that in all breech-loading guns we must have some form of metallic cartridge (leaving out those india-rubber wads of which I have been speaking), in order to ensure sufficient gas closure. The tubular bullet is, or may be, made a metallic cartridge. When that is the case it is closed by a wad behind. I think it would be worth while to illustrate this to the meeting, for perhaps they may not have understood from the bullet alone exactly the way in which it is proposed to employ it. I will draw a section of a tubular bullet, pure and simple, without the rifling inside, as you see it has a wad behind. This wad has some arrangement for fulminate, either in the ordinary anvil and cup way, or in some other way, behind it. When the bullet is fired the air rushes into it, drives off the wad as it leaves the gun, and thereafter the bullet threads itself on a column of air, and passes through it, not only with lessened resistance in front, due to its tubular form, but with lessened vacuum behind, due to the passage of the air through it. Whereas, if I draw a section of precisely the same bullet, with a flat head, I should get this. The air passing off from the front and over the sides of the flat front re-unites again, but leaves in the rear a vacuum which is called the point of non-pressure, and which is equal to an added resistance in front. This is absent in the tubular bullet, and leads to an explanation of the fact of the lessened trajectory and increased range. I should also have the full resisting area in front.

The tubular bullet, charged with powder, becomes a metallic cartridge. The operation of firing them is this: a bullet is taken out of the pouch, and the powder is shaken out, and thrown away. It is then pushed into the breech-loader. A second bullet, with the powder in, and with the wad, of course, behind, as well as in the first, is then pushed in. The explosion in the second bullet leads to the expulsion of the first bullet. That second bullet is then pushed forward, and is changed from being a cartridge to becoming a projectile; it is then expelled in its turn. The weight of this 120 grain cartridge case, or we will take it as low as Captain O'Hea has put it, at 106 grains, is a very important element, when you come to deal with a number of cartridges. This element of weight would be absent were it possible to do away with those cases. The tubular cartridge also carries out the views of those who have expressed themselves very strongly throughout the whole question, viz., that the grand idea of a gun firing a cartridge loaded at the breech should be to expel that cartridge altogether. It has all the advantages of a metal cartridge, and leaves no more in the barrel after firing than a perfectly burnt paper cartridge would do. The expense of manufacture also is another item, which, I think, may be remarkably reduced. It is a question, no doubt, of a new manufacture; but we all know perfectly well that in the outset of a manufacture, conditions are present which are very speedily eliminated by those who engage in that manufacture, and who study the reduction of the pence that go to make up the pounds. Fouling also is a subject for very extended experiments. I have found it in the same gun, with the same powder, and the same bullets, to be the result of differences in the

barometric pressure and the state of the atmosphere generally. It is a subject not understood, I believe, at the present time; yet it points to the conclusion that it is perfectly futile to fire any number of guns to ascertain the causes of fouling, unless you do that under the same conditions of weather, and also under the same conditions of time. Therefore, I should like to eliminate that as an error which would disturb any philosophical conclusion on the subject. Let it be understood that there are barometric and atmospheric disturbances which do interfere with that conclusion. The question of bullets, which has been so ably brought forward by General Boileau, I would only further advert to by saying that, in my own experience, I have found invariably that the so-called plug behind falls out before the bullet has attained its distance. I have fired at a long range of 2,000 yards against a chalk hill, which is lightly covered with earth, so that I recover all my bullets nearly in the same state in which I fire them. I find the bullets invariably spread out, and get deformed in proportion to their variation from the solid form; that that solid form is the one in which you get the full development of the specific gravity; that any departure from it invariably leads to lessened penetration and higher trajectory. In fact, as we might have supposed, from the very fact that they employed lead in our bullets, no metal of lesser specific gravity suffices us. It would be unwise, for the sake of an accuracy, which may certainly have its value at long range to Volunteers, but which has a very small value indeed to military men, to engage in a form of bullet which, though it gives us increased accuracy, invariably gives us lessened penetration and a higher trajectory. And I should not be found advocating the form of the tubular bullet unless, combined with the column of air passing through the bullet, there was that lower trajectory and that increased penetration, which is the natural result of a higher velocity.

Mr. James D. Dougall: Mr. Chairman and Gentlemen,—The subject of the paper and the remarks since have applied almost entirely to the shape of the cartridge and the weight of the projectile. Very little, indeed, has been said upon the nature, the quality, or the explosive force of the powder by which the expulsion of the projectile is to be gained. When I was invited to attend this meeting, I really did not know what the subject of the paper to be read was; therefore, any remarks I have to make, I beg you will bear with, as they are entirely *extempore;* but I think you will find that they bear upon this subject. Before saying one word upon the gunpowder, I have great pleasure in testifying to the correctness of Mr. Macintosh's system of tubular projectiles. I have been experimenting upon it for some considerable time for sporting purposes; and I entirely agree with Captain Selwyn as to the increased velocity and the consequently lower trajectory it obtains. The breech-loading system has reached a point which not only demands the greatest possible investigation into the best form and weight of the cartridge and projectile, but also into the nature of the powder. The position that I am prepared to maintain is this, that an entirely different gunpowder must be found; not what is commonly called black gunpowder, but a powder as nearly as possible possessing the same qualities as black gunpowder, but wanting its faults, and as nearly approaching the qualities of gun-cotton also, but wanting its faults; in fact, the *juste milieu* must be found. I am prepared to state my belief that it has been found; found by the invention of Captain Schultze, of the Prussian Artillery, perhaps one of the most distinguished practical chemists and officers of Europe, who I am proud to say is in this room. Captain Schultze's powder may be said to be almost entirely common gunpowder, with this great difference, that his wood is not charred. The gases which are thrown off in the retort used for charring the wood, he prudently saves, and burns them in the gun itself, where I say they ought to be burned. Instead of being thrown away they are reserved; the consequence is, an immensely increased amount of projectile force, less rending force, less fouling, and greater regularity in shooting. In the month of October, 1865, my attention was first drawn to this powder. I investigated it very closely, and shot a good deal with it. I also went over to Potsdam, and spent many days there with Captain Schultze, investigating its chemical qualities; and I returned with the perfect conviction that this powder must take the place of all other powders. Since then, it has been introduced into this country, but unhappily not

under circumstances likely to bring it favourably before the public notice. But its position on the Continent is now this: it is being gone into on an immense scale at Spandau, by the Prussian Government, and every week there is a record made of the results. In Belgium it has not been taken up by the Government; but it is being taken up by a capitalist, Baron Van Aacken, who after a thorough investigation, is about to embark in a large way in its manufacture. In France, experiments have been carried on during the months of December, January, and February, at Vincennes. The result of these scientific experiments at Vincennes, is a report signed unanimously by a commission of officers, all recommending its use for the Chassepot; and the French Government are about to institute a series of experiments on an immense scale at Cherbourg.* The quality in which this powder surpasses gun-cotton is that it is under perfect control, while gun-cotton, if it has no other faults, is ungovernable.

The CHAIRMAN: The only difference is that the wood is not charred?

Mr. DOUGALL: The only practical difference. While gun-cotton is a vegetable substance prepared with acids, this is merely washed with acids. It is cleansed with lime, washed with acids, for a certain reason, and then, finally treated with the saltpetre itself.

General BOILEAU: What is its specific gravity as compared with black gunpowder?

Mr. DOUGALL: About one-half, as nearly as possible. The charge of the Chassepot rifle with the black powder is 5½ French grains; with this it is 2¾ grains, exactly one-half the weight of powder. The projectile force, I should say, is something in the proportion of 45 to 31, *i.e.*, using only one-half the weight of the new powder.

Captain TUPPER: Is there any sulphur in the powder?

Mr. DOUGALL: Not a grain. Sulphuric and nitric acids are combined in the first instance to produce chemical action, and drive the nitric acid into the wood. Afterwards the sulphuric acid is entirely removed; there is not a trace of it left.

Lieut.-Colonel FLETCHER: What is the relative strength of this powder, as compared with ordinary gunpowder?

Mr. DOUGALL: The relative strength is much more than double. We use one-half the weight. [Mr. Dougall here showed a Chassepot cartridge loaded with the new powder.]

Lieut.-Col. FLETCHER: Is that the charge for the Chassepot rifle?

Mr. DOUGALL: That is the Chassepot charge, exactly as it is used at Vincennes.

Lieut.-Col. FLETCHER: But the charge for the Chassepot cannot be double the size?

Mr. DOUGALL: The new powder is double the bulk of black powder. We use one-half the weight, so the size of the cartridge remains the same.

Admiral Sir HENRY CODRINGTON: What is the effect of Schultze's powder upon the arm?

Mr. DOUGALL: The effect is extreme diminution of the rending force. That was ascertained in the last experiments made at Vincennes a fortnight ago, by an apparatus carefully made for the purpose. It was found to possess less rending force than any powder that had ever come before the French Government.

Sir HENRY CODRINGTON. And the chemical effect upon the metal?

Mr. DOUGALL: It is perfectly innocuous to the metal. The claims for the powder are, its greater regularity; its greater force; it does not cause recoil; and it does not foul. On one occasion at Spandau, on going into the question of fouling, they fired 460 shots without cleaning the gun. The superintending officer then said, that it was no use going any further.

Captain BURGESS: Was a breech-loading cartridge used?

Mr. DOUGALL: A breech-loading cartridge was used. Captain Schultze can correct me if I am wrong, in saying that there were 460 shots fired.

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* Mr. Dougall here gave a brief description of its manufacture, a full description of which will be found in a paper read on the 30th March, and published in this number of the *Journal*, page 127, *et seq.*—ED.

Captain SCHULTZE: Yes, 460.

Lieut.-Col. FLETCHER: With reference to its durability?

Mr. DOUGALL: Its hygrometric qualities are slightly greater than those of the black gunpowder, in the proportion of 2·80 to 2·20; but the effects are only one-half. This was tried by storing six casks of each powder in the dampest casemate that could be found at Spandau, after careful registry. After six months both powders were used again, at the same elevation of 1,200 feet. The black powder had increased its dampness in the proportion of 2·20, but its projectile power had diminished 8½ per cent.; the Schultze powder had increased its dampness at the rate of 2·80, but its shooting power had only fallen off 4½ per cent., about one-half the other. The cause of that is the not having removed the hydrogen in the powder. The hydrogen in the Schultze is analogous to the gases in the powder; consequently, they are consentaneous in their action, more consentaneous than in the black powder. That is the solution of it, I believe. I have nothing more to say upon this great invention, except that I am prepared to answer any questions if any gentleman would wish to ask any.

General Sir WM. CODRINGTON: Am I to understand that neither sulphur nor saltpetre is used?

Mr. DOUGALL: That is a great point, that while the gun-cotton is treated with acids, the saltpetre is here in a solid substance, by the application of a powerful microscope, you will see it glittering.

Captain SELWYN: Is there any trace of sulphuric acid?

Mr. DOUGALL: Not a trace. This is prepared with nitric or sulphuric acid very weakly, but the sulphuric acid is entirely removed.

Captain SELWYN: It is hard to say why it is put there.

Mr. DOUGALL: It is put there for the chemical action. The sulphuric acid is used to produce a chemical action to drive in the acids, but the sulphur is entirely removed afterwards.

General BOILEAU: Does this powder give much smoke?

Mr. DOUGALL: Very little. It is somewhat curious that when the combustion of black powder takes place, of the gases evolved only 31 in the 100 are driving powers, and 69 are inert; while in this powder 90 in the 100 are driving gases, and only 10 are inert.

The CHAIRMAN: Would you ignite a small quantity of the powder?

Mr. DOUGALL: With pleasure; I will hold this cartridge in my hand between my fingers, and show that there will be no recoil. I will put the equivalent of three drachms of black powder. [Mr. Dougall here showed the experiment.] With the black powder you would see the flame, &c., spreading out like a mushroom; with Schultze's powder you see that the gases rush out consentaneously. With regard to cost it will be very much less than gunpowder. The process of manufacture may be under 72 hours. It is impossible there can ever be any accident to human life. The powder is all made in large tubs, by women.

Lieut.-Col. FLETCHER: Has the uniformity of shooting with this powder been tested with rifles?

Mr. DOUGALL: Yes; this very day a party of military and scientific gentlemen tried it, and made a much flatter trajectory with it. If I were to cram in as much powder as I possibly could, we should get a lower trajectory still.

The CHAIRMAN: Have the Prussian Government adopted it?

Mr. DOUGALL: They are going on with experiments now that will last till next January, because, as I said just now, every week there is a fresh report. It has been perfectly successfully tested for small arms.

Captain SELWYN: May I suggest that Mr. Dougall should give us a detailed paper on the subject, because it is hardly doing justice to Captain O'Hea's paper to leave it undiscussed?

The CHAIRMAN: It would be very desirable.

[Before closing the subject Mr. DOUGALL ignited a small quantity of the powder on an earthen plate. After the ignition there was a small quantity of residuum left. This residuum, he explained, does not exist when the powder is fired in the gun; it is burnt, and goes off with the smoke. He mentioned that one of the Commissioners

superintending the experiments at Vincennes had himself recently brought out what he considered to be a very great improvement in gunpowder. Captain Schultze's powder could not by any possibility have met with a more dangerous rival. One of the improvements which this French General Officer claimed for his powder was the reduction of smoke. It was accordingly proposed to test the two powders in a room. Captain Schultze's was tested first. They fired 30 charges in the room without creating anything unpleasant. After 6 charges of the other powder the inventor begged that the experiment might be stopped, and he was one of those who, with the greatest pleasure possible, signed the unanimous certificate in favour of the superiority of Captain Schultze's powder.]

Mr. Stirling Lacon: The residuum on the plate looks like fouling.

Mr. Dougall: Yes, because combustion of the powder is not complete in the open air.

The Chairman: We have to some extent wandered from the subject which Captain O'Hea has introduced. Still the remarks have been interesting and valuable, and I think it is a subject that might be very usefully brought before this Institution. I am, however, anxious to bring back the discussion to the original subject. I do not know whether any other gentlemen wish to make remarks upon Captain O'Hea's paper before we conclude.

Lieutenant-Colonel Fletcher: There are a few remarks which I should wish to make. It is a subject I do not wish now to go into, and there is very little to be added after Captain O'Hea's very valuable paper and Captain Selwyn's remarks. The only point that I should like to touch upon is regarding what Captain O'Hea said with reference to the Chassepot rifle. I think it must be satisfactory to us to know, that at present, with reference to the arms of our infantry, I believe we are superior to any other nation. I am not speaking of the future, or how other nations will be armed, but as far as regards the comparing our own arm, especially with the Chassepot, I think that we are in possession of a much more useful and more serviceable arm than foreign nations. Supposing we were called on for foreign service at once, I think we should have an advantage.

The Chairman: Perhaps Captain O'Hea would wish to make some remarks in reply.

Captain O'Hea: I only wish to ask Captain Selwyn a question with regard to the Macintosh tubular bullet. In all tubular bullets containing a charge of powder, the powder case expands on the explosion of the charge. It, therefore, fits the barrel excessively tight. Is there any difficulty in moving the tubular cartridge forward when you wish to make it a projectile? You have to push it forward to make it become a projectile for the next round. Is there any difficulty in that?

Captain Selwyn: I may answer that by saying that the ordinary requirements to which Captain O'Hea before adverted, although they apply principally to rifles, apply, in some degree, to smooth-bores, from which it is proposed to fire this projectile. For even in a smooth-bore you require some measure of elasticity between the bullet and the fire-arm. That is obtained in this instance by a wrapper, or envelope, which may be made of tough paper, but which I should prefer being made of something more nearly approaching to felt; very thin, still a felt containing a lubricating material. Under these circumstances the felt is subject to compression, but its elasticity enables the bullet to be pushed forward.

Captain O'Hea: I have only to express my thanks to General Boileau for reading my paper, and also to Captain Selwyn and other gentlemen for the remarks they have made.

The Chairman: I am sure that the meeting will thank you for having written the paper, and also General Boileau for having read it. It is a very valuable paper, and also the remarks which have been made by General Boileau and by Captain Selwyn have been most valuable in illustrating this much vexed question, and one not yet completely settled.

Evening Meeting.

Monday, March 30th, 1868.

Rear-Admiral SIR FREDERICK W. E. NICOLSON, Bart., C.B., Vice-President, in the Chair.

NAMES of MEMBERS who joined the Institution between the 16th and 30th of March.

ANNUAL.

Kerr, Henry, Capt. 7th Royal Fus. 1*l.*
Whitehead, F. G., Lt.-Col. 29th North Mid. Rifle Vols. 1*l.*
Moysey, C. J., Capt. R.E., 1*l.*
Cohen, Lionel B., Lieut. Tower Hamlets Eng. Vols. 1*l.*
Leith, James, V.C., Major, late 2nd Drgs., Hon. Corps Gent.-at-Arms. 1*l.*
Hales. Arthur, Lt. Cape Moun. Rif. 1*l.*
Kendall, William, Col. R.E. 1*l.*
Boxer, C. F. R., Capt. R.N. 1*l.*

SCHULTZE'S GRANULATED-WOOD GUNPOWDER.

By Mr. James D. Dougall.

Before entering upon the immediate subject of this paper, I crave your indulgence for a brief space to explain my position and connection with it. In October, 1865, I was waited upon by two gentlemen, both of whom, I believe, are now present, but who were at that time entire strangers to me, who showed me specimens of this new powder, of which I had not previously heard. Having, so far back, as in a work of mine published in 1858, but written in 1857, expressed an opinion, that we were on the eve of some great invention in explosives, I naturally gave the matter some attention, and, having since then seen no reason to alter the favourable opinion I formed of the powder in the first instance, my name has gradually become connected with its introduction into this country. But, my appearance before you this evening is not in the character of a partizan or a speculator. I have no money whatever embarked in the matter, and all I can lay claim to, is an honest and energetic resolution to satisfy my own mind in the first instance; and, in the second, if so satisfied, to give publicity to my convictions for the general good. For this purpose, I have experimented with it practically on a large scale with rifle and smooth-bore guns.

I have visited the manufactory or powder mills at Potsdam, and, I may say have exhausted the subject so far as it affects practical or sporting gunnery, by examination of the mode of manufacture, and, if I may be permitted the use of the term, by *cross-examination* of the talented inventor, Captain Edward Schultze; and, finally, by every practical test I can think of as necessary. I take this opportunity to pass a slight and most imperfect eulogium upon Captain Schultze, a man whom I consider it an honour to know, who, above all degree possesses the most remarkable combination of sense and sentiment I have ever known, and who meets every investigation of the merits of his invention in the frankest spirit. You will shortly be told how this sensitiveness of character bore directly on the invention now before us. I confess that I was not prepared for the remarkable knowledge he displayed of the theoretical nature of this powder—that is to say, that certain results I had practically arrived at for myself, but for the causes of which I could not account, were by him explained in figures, and to minute decimals of the most satisfactory and convincing character.

The history of the powder is as follows:—Captain Schultze, a considerable number of years ago occupied the same position at Spandau, as the talented Mr. Abel now does at Woolwich. At once an artillery officer and a chemist of the highest attainments, he was chief of the *fonderie*, but the Prussian Government's attention having been drawn to gun-cotton, to Captain Schultze was given the important task of solving the question—Is gun-cotton an available explosive for military purposes? He was therefore removed from the *fonderie* to the chief charge of the Gunpowder department. In that position, with every requirement at command, he for years experimented on gun-cotton, and at last gave in his final opinion against its adoption, describing its character in these emphatic words, "It possesses the *beau-ideal* of force, but is quite uncontrollable."

During these experimental years he was also engaged (in the exercise of his official duties) in the daily manufacture of black gunpowder, so that he was master of his subject from the two points of view bearing upon these great rivals, gunpowder and gun-cotton, when an accidental circumstance sent his energies in a fresh direction. A brother officer had been present at Mayence, on the Rhine, when the tremendous explosion of the powder magazine took place, which must be fresh in the recollection of many gentlemen now in this room. Captain Schultze had spent many happy days of his life in Mayence; I have already told you that he is a man possessing much sentiment in his nature, in a word, a man of both quick and deep feelings, and he was so horrified by the details of his friend's description of the effects of the explosion, that he then and there resolved to devote the remainder of his life to the discovery of a powder capable of being manufactured and stored without risk to life or limb. After years of labour and the trial and rejection of nearly every vegetable substance within his reach, he succeeded in the production of this granulated or raw uncharred wood powder, the subject of this paper, and which, after these preliminary remarks, I shall now proceed to describe.

Captain Schultze had, impartially and without prejudice, already arrived at the opinion of the worthlessness of gun-cotton as a trustworthy explosive. He had the most perfect confidence in the propulsive powers of black gunpowder. He did not, and he does not now, depreciate or disparage the merits of the latter, which for centuries has well done its work, and has been one of the chief agents in the promotion of civilization. He set himself to the task of modifying the nature of that black powder, adopting it as a standard of explosive qualities, but being resolved to remove what he considered its objections, and principally these—1. Danger in manufacture and storage; 2. Heating and fouling of the gun; 3. Undue recoil. Other minor matters I have no occasion at present to refer to.

Starting from the position that all explosives should be composed of a granulated substance, the thought at last struck our inventor, that, he might attain his object by means of a powder as nearly approaching black gunpowder as might be, but with the wood uncharred, with little or no sulphur whatever, and above all, with the presence of saltpetre or its equivalent, in solid substance; in a word, an explosive occupying the *juste milieu* between the pyroxyline proper on the one hand, as *gun-cotton*, and black powder on the other. Still giving all due regard to the great merits of the latter, he chose those woods, as the alder, which give the best charcoal ingredient for black powder, at least for fire-arms, and he proceeded to granulate that wood in different sizes of grains, by which as in black powder, the rapidity of combustion is governed. But here, let me mention, *in limine*, that there exists a great difference in the conditions for the government of the rate of combustion, if indeed, with regard to the size of the grains, it be not in the inverse ratio to that of black powder. Hence grave errors have been, and to my knowledge, are now being made by experimentalists, who, however well versed in testing the shooting powers of black powder, have, without seeking advice or guidance from Captain Schultze or his agent, rashly experimented, in small bore rifles for instance, with his powder as made for quite other varieties of fire-arms. Equally deceptive and fallacious results would follow the use of fine-grained black powder where large-grained is required, or *vice versâ*. This caution is all the more necessary, that Captain Schultze is now making seven varieties of powder, and I believe that one or more of these has also sub-varieties.

Here, for a purpose, which will now explain itself, I must, with your permission, pause in reading this paper, to initiate one of the more practical purposes of the evening. I shall have occasion to observe that Schultze's powder may be wetted without caking, and be dried without diminution of its force. I shall now wet a small quantity of it in your presence. Ten per cent. of water, I may here mention, may thus be added to this powder without diminishing its force when re-dried, for this reason, that, with that amount of water, the salts are not dissolved. [Mr. Dougall here poured water upon a small quantity of the powder in a wine glass, and handed it to the serjeant in attendance to be dried.]

The wood about to be used is kept in water, so as to give it tough-

ness and adherence under the saw. By fine saws, which can be set so as to govern the size of the grains, the wood,—alder by preference, to which next ranks the *rhamnus* of the ancients, I am not certain of its popular name, if it be not "*buckthorn*,"—is cut into cross veneers. These veneers are again punched out into grains. The remaining part of the veneers, after passing through the punching-machine, is utilized by further processes. The main bulk of the wood, you will have an opportunity to observe, is cut into little solid blocks, their size being governed by the setting and thickness of the saw, and the size of the punches. Mere *débris*, or sawdust, a word which has been unhappily connected with this powder, does not at all suit the purpose. The grains must be, as I have described, cubes or rectangular parallelograms, and, by the kindness of my neighbours, Messrs. Murray and Heath,—gentlemen who are always willing to promote science for the sake of science, and not in the mere business sense,—you will have an opportunity of examining these grains through powerful microscopes. Some *débris* will of course be found to exist, its partial or complete removal being a question resolved by desired requirements. After the grains have been so produced, they are submitted to various processes for the removal of acids and other easily soluble substances, after which they are in a condition to receive the first impregnation of an explosive ingredient. Forty parts by weight of concentrated nitric acid 1·48—1·50 are mixed with 100 parts by weight of sulphuric acid (sp. gr. 1·84). This mixture is set aside in some cool place for use. To 100 parts by weight of this mixture are six parts by weight of the prepared grains gradually added, stirring the whole constantly for two or three hours, when this part of the operation is completed. The presence of sulphuric acid is required solely for the purpose of creating a chemical action, by which the nitric acid is driven into the wood. Part of that nitric acid forms a chemical combination with the wood, and remains fixed there. The other part, and the whole of the sulphuric acid are withdrawn from the wood by subsequent operations. I request your especial attention to this great fact, the withdrawal of the sulphur, for on it rests much of the excellence of the powder, and I do this with the greater confidence that, a doubt of this having been expressed by a gentleman of authority on fire-arms at your meeting on the 16th instant, I have pressed the question on Captain Schultze, on whose word I have the most perfect reliance, and he assures me that there is no appreciable TRACE EVEN of sulphuric acid left in his powder, and that his sole reason for mixing it with the nitric, is to drive the latter into the wood, or create a chemical action, by which the wood and the acid form a combination according to a well-recognized law in chemical science. Indeed I know, practically, that the sulphuric acid, so withdrawn, is again utilised, and that at first considerable loss was occasioned by it being allowed to escape.

The grains of wood, now combined chemically with a certain amount of nitric acid, are freed from the merely mechanically adhering remainder of the acids by a centrifugal machine or other process, are placed in cool, running water for a considerable number of hours, afterwards boiled in a weak solution of carbonate of soda, again placed in

running water, and finally are dried and stored, or immediately, if desirable, converted into the finished powder.

I shall now burn some of the grains in this incomplete state. You will observe that their inflammable qualities scarcely exceed those of dry sawdust. In this state they can be kept for any reasonable period, and even in a damp state for safety in shipment or storage.

The whole of the above processes being conducted in a wet state, there is absolutely no danger of explosion attending them. Those who have visited Potsdam must know that it is the pet place of the Royal family of Prussia, a town of palaces and churches, with beautiful environs. So strict are the police laws, that Captain Schultze is not permitted to fire a rocket there, even for the purposes of experiment, or to show to inquirers like myself the immense height to which he can drive that form of projectile with his powder. But, in this beautiful town, certainly not in its centre, but still within its precincts, on ground only divided by a low paling from his own garden, and with neighbours' houses on each side, is the powder manufacture carried on up to this stage. I had the curiosity to measure the nearest point (from the much more extensive factory than I was prepared to see) to Captain Schultze's residence, and found it exactly 45 feet. But I saw something still more unexpected, and that was, Captain Schultze's chief chemist smoking his cigar daily while occupied in his practical duties in a gunpowder manufactory. The grains in this stage are, at Potsdam, now conveyed to Captain Schultze's magazine, situated about two miles from the factory. They are there treated finally with nitrate of potash (saltpetre), or, what I believe Captain Schultze prefers for most varieties of his powder, nitrate of barytes. [Mr. Dougall here read from the Patent Specification the description of this process (page 5):—]

The powder is now complete, and being dried by exposure to a temperature ranging from 90 to 112 Fahrenheit, for a space of 12 to 18 hours, is now ready for use. Even now the danger of accident from explosion is not great. This was on one occasion somewhat sharply tested. Fifteen cwt. of powder in its perfect state was contained in a large iron vessel, having a horizontal flange. A merchant coming to purchase a quantity of the powder was taken, by an assistant, in the absence of Captain Schultze on military duty, to the magazine. A small quantity of the powder was placed on the flange, and ignited with a lucifer match, and both men withdrew immediately afterwards, leaving no apparent cause of mischief. The door was hardly shut and locked, however, when flames burst through the roof of the magazine, a rapid deflagration, but no actual explosion, followed, the copper pipes used for heating the drying-room were melted, but there was no concussion whatever. Although this misadventure cost Captain Schultze a considerable sum, I have heard him say that he never expended money with so much satisfaction, for it proved that his powder, so powerful in fire-arms or in blasting, when unconfined or loosely confined was comparatively harmless.

We have now arrived at the complete powder. This, I have already stated, is made in at least seven varieties, all differing in force as

required, thus proving that its manufacture is under scientific control, and not a merely fortuitous process.

I must here confess a reluctance to describe or dwell upon these various forces. I repeat that I do not treat the subject in the spirit of a partizan. I know the claims of our English gunpowder, its power, its regularity, and its general excellence. Where I am compelled to draw comparisons, it is where I have no other standard of excellence, no other power of illustration. I shall briefly, however, tell you what I have seen done with one variety of this powder. I have seen half an ounce of it only, enclosed in a small glass bottle, such as you may purchase dissolved gum-arabic in, sunk in two feet of water, throw a column of water, containing I know not how many gallons, to a height of 21 feet. Exactly the same quantity of black powder, fired in the same spot, in a similar bottle, hardly elevated the surface of the water, and only produced an ebullition. At my special request, although those present could not understand my purpose, $1\frac{1}{2}$ ounces were then sunk in 15 feet of water. The effect of the explosion was marvellous. I myself was standing at a distance of eight or ten yards from the margin of the river, when, without any noise being heard, I found a violent vibration under my feet, consisting of I should say, five distinct pulsations of the earth. Gentlemen, now in this room, standing at a much greater distance, described the vibration in equal terms. Vast quantities of mud, branches of trees, vegetable remains, and such other substances as may be looked for at the bottom of a river, came to the surface, and, finally, dozens of roach and other fish, in a stunned state mostly, only a few being apparently quite dead. I conclude from the large number of these fish, and their different degrees of suspended animation, that the shock must have extended over a large space of water. On the land the vibration must have extended over at least the space of an acre. This was, I remind you, all done with $1\frac{1}{2}$ ounces of Schultze's powder, as specially prepared for mining purposes, for coal or soft rock; other varieties, quite differing in effect, being prepared for blasting hard rock. What the power of such powder may be in a shell or torpedo, it is frightful to contemplate.

I have purposely, by way of dramatic contrast, described to you the effects of this terrible variety of powder, that what I am about to show you may be the more striking.

I have now in my hand a quantity of the regular sporting powder. You see how comparatively slowly it burns, how rapidly the gases ascend, and with what I may call harmony or consentaneousness they do ascend. All these qualities are elements of correctness of the explosion, for it is by them that Captain Schultze claims great reduction of recoil without any loss of propulsive force.

The exact qualities of the various gases evolved by the combustion of gunpowder or other explosions, I do not pretend to be able to discuss. But, as Captain Schultze has, in a pamphlet or pamphlets published in the German, French, and English languages, given publicity to not only the results of his own analyses, but to those of other distinguished continental chemists, I venture to express a hope that in the following statement I shall not be accused of any invidiousness or mis-

representation. Captain Schultze, then, asserts that, when we burn black gunpowder we evolve 31 per cent. of active and 69 per cent. of inert or even obstructive gases. He argues that these 69 volumes of gas, in the proportion of more than two to one, repel the onward or propulsive motion in a great degree, and cause an increase of recoil. He illustrates this assertion by the following simple experiments. [Mr. Dougall here burned the fill of an open Lefaucheux cartridge fastened to the end of a slender wire in a horizontal position. The wire never vibrated or bent; but when the same cartridge was *one-third* filled with black powder, the recoil was so great that the wire was bent forcibly downwards, and the cartridge was driven right under his hand, in which position it remained.]

He also asserts that a large part of the inert gases rapidly recondense, and so foul and heat the gun.

On this part of the question, I cannot speak authoritatively, much less dogmatically. Captain Schultze's theory is certainly largely borne out in practice, but, speaking impartially and dispassionately, I think that we can arrive, theoretically, at very little exact knowledge of the comparative powers of gases as evolved from explosives in a state of confinement, as in a gun. The expansion must be governed in a great degree by the degree of heat. That heat I should be inclined to term immeasurable. I, therefore, even were I competent to discuss the more intricate and chemical branches of my subject, must avoid such discussion. Were Captain Schultze himself present, I might take a different course, but he is now so closely engaged at Paris, with the French Ministers of War and Marine, and other officials, that he could not possibly attend this meeting, although both strongly urged and being himself desirous to be here.

Having stated his theory of the explosion of black powder, I now give that of his own. For *it*, he claims not less than 90 per cent. of active ordinary gases, and only 10 per cent. of inert! This difference, if borne out in practice, is literally astounding, for even with one half of the weight of charge, which is his professed equivalent, we have 45 driving powers, with 5 inert, against 31 driving powers, and 69 inert, in the charge of a firearm!

But I should be deficient in moral courage did I not acknowledge that experiments, startling as the statement may appear, largely bear out these assertions. Of one of these I shall now give the results, first stating that I shall not take up your time by giving exact fractions, but giving you sufficiently approximate returns. I constructed a target, running on wheels, upon a framework of iron. It is not a highly scientific target, in so far as it cannot register by measure or weight the exact force with which it is struck, but it must of necessity correctly measure comparative force. At this target, from the same breech-loader, were fired a large number of shots with gun-cotton, with gunpowder, and with Schultze's powder. I may dismiss gun-cotton at once by stating, to use a sporting phrase, it was "nowhere," and now I never think of taking it into consideration. The last experiment made was, as usual, with 82 grains = 3 drachms of black powder, and an equal bulk, something slightly over half the weight of Schultze's

powder. The charge of shot was $1\frac{1}{8}$ ounces of Walker, Parker, and Company's No. 6. I consider this a fair test, because we can arrive at some degree of accuracy in our summing up, whereas with a single ball, or measuring velocity by that most fallacious of all tests, penetration by a soft leaden bullet (I do not include, in this prevalent and mischievous fallacy, penetration by a projectile of any metal hard enough to retain its shape and not be flattened) no approach to comparative calculation can be attained. I can also, at such a test, bring into use my trained judgment as a practical gunsmith.

The result was as follows:—

Aggregate pellets of 6 shots.

Schultze powder	..	1150	Motion to target ..	$10\frac{1}{8}$ in.
Black powder ..	..	1016	Do. do. ..	$6\frac{4}{8}$ in.
		134		

Now the value of this experiment lies in this, that if we add the above 134 pellets to the 1016, aggregate of the black, being about $\frac{1}{10}$th of the aggregate of the Schultze pellets, we may extend the dislodgment of the target by the black powder also $\frac{1}{10}$th, say $\frac{5}{8}$ths of an inch, near enough for our purpose. This gives $7\frac{1}{8}$ inch motion against $10\frac{1}{8}$. Now, $7\frac{1}{8}$ inches are equivalent to $\frac{57}{8}$ths of an inch, and $10\frac{1}{8}$ inches to $\frac{81}{8}$ths. By the simple rule of three we find, then, that if 31, the driving powers of black powder, asserted so at least by Captain Schultze, give this $\frac{57}{8}$ths, his powder should, if it really possess 90 per cent. driving power, give $\frac{82}{8}$ths and a fraction, with one-half the weight = 45. We have found that it gave exactly 81, an approximation so remarkable, that we can hardly attribute it to chance. Gentlemen now present can testify to the impartial exactness with which this experiment was conducted.

31 : 57 : 45 (being one-half of the 90 per cent.)
45
———
285
228
———
)2565($82\frac{23}{31}$
248
———
85
62
——
23

From experiments with small shot we come to those with rifles. In this branch of practice I have confined myself to my speciality, sporting rifles. I am not now, and at no time have been, occupied with military rifles, but, using immense charges in my guns for heavy game, I naturally have anxiously and closely tested this new powder on my

own behoof, because, if I can find an explosive giving great velocity, with little recoil, and no smoke to speak of, I can put into the hands of my friends in India and elsewhere, weapons possessing great advantages where, as in the jungle, the pursuit of ferocious animals is attended with considerable personal danger. Independently of other considerations then, where life itself may be at stake, I am bound to be more than usually guarded in the recommendation of any new explosive. I now produce a sheet of iron, $\frac{3}{16}$ths of an inch thick, fired at from 100 yards distance, with one ounce spherical bullets of pure soft lead. You will be able to judge of the comparative velocity for yourselves. I may appear to contradict myself after what I said a short time ago, in thus appealing to penetration for a measure of velocity, but the penetration of a single sheet of iron as this is, without being backed up with other substances, whose reaction can be brought into play, is very different from the penetration of such a backed up substance, or from layers of substances in *contact* with each other. As a comparative measure of velocity, it is a fair and handy test.

The rifle used in this test was a 16 gauge Lockfast breech-loader. The charge of black powder was 4 drachms, about 109 grains, No. 6, that of Schultze powder being equal volume, or as near as may be one-half in weight, or 54 to 55 grains. The results are before you in this plate. I shall not pretend to claim a victory for either explosive. They have both done their work well, and so nearly on an equality, that it may be difficult to distinguish any appreciable difference. I think it proper to state that the Schultze powder used was sporting powder, not rifle. My reason for this was that I wished to try the shooting with such powder as would be likely to fall into a sportsman's hands. Whether or not a still greater velocity might have been obtained with Schultze's rifle powder, I am not prepared to state; but I understand that it is manufactured of greater strength than that of sporting powder.

In direct connection with rifle shooting, I am in a position to inform you that after prolonged trials at Vincennes, extending, with short intervals, over three months, the Committee of Officers appointed by the French Minister of War to superintend the experiments, although at first very dubious of the good qualities of the new explosive, and indeed prejudiced against it, through confounding it with some other powder, unanimously signed the report recommending its adoption in the French Army. The conditions were that it should excel the French gunpowder on six points, viz.:—

1. Absence of fouling.
2. Absence or diminution of smoke.
3. Diminution of recoil.
4. Reduction of heat, so as to permit more prolonged shooting with the Chassepot rifle, the weapon used for the trials.
5. Greater initial velocity and regularity of shooting.
6. Reduction in wrenching or bursting force.

On all these points Captain Schultze was successful, and the report was signed accordingly, as I have said.

In this country, a gentleman of high scientific attainments, a Fellow

of the Royal Society, and well qualified for the task, has experimented largely at 800 yards' range with this powder in the Snider and, possibly, other rifles. His experiments have been carefully and slowly conducted. They are not yet concluded, but they have hitherto given every promise of success.

In very elaborate experiments now being conducted at Spandau, the same success has hitherto attended Captain Schultze's invention. I may state here, *par parenthèse*, that although in Belgium the question has not been taken up by the Government, a well-known nobleman and capitalist of that country has arranged with Captain Schultze for the manufacture, and is about to erect extensive powder works.

The last, and in one sense the greatest, branch of this subject, so far as it treats of propulsive force, is the adaptability of this explosive to cannon. As an Artillery Officer, Captain Schultze is here quite at home. Indeed, it was his practice, when in service, to load one-half of his battery with black powder, and the other with his own. What he particularly claims, however, for this branch is the almost total absence of smoke, and great reduction of wrenching force and recoil. It must be known to you, Mr. Chairman, and to many other gentlemen in this meeting, that no heavy marine gun has yet been made by the French, capable of standing 45 rounds with full charges of English gunpowder. Consequently, the French are now in anxious search of a more suitable explosive, and that is the next task set to Captain Schultze. Immediately on his obtaining satisfactory results at Vincennes with small arms, he was handed over by the Minister of War to the Minister of Marine, and we shall shortly hear of what will have been done on an extended scale with heavy marine cannon at Cherbourg.

But the French are going still further. I beg that what I am now about to announce may be taken at its actual value. Hitherto I have stated Captain Schultze's claims from facts and experience. What I am now going to mention is hypothetical, and it is that several men of science in Paris, including the Emperor himself, believe that in this powder they have discovered what they have long sought for, a "*motor*," to take the place of steam in sea-going vessels. This is a most important matter; not in these days of scientific progress to be dismissed with a sneer as the dream of a visionary. I am quite aware of the danger of over-stating a case, but I beg of you to bear in mind that this is, at least, no dream of Captain Schultze. He has been shown the machines as already constructed, and has been told their requirements. The question has been put to him, can you give us an explosive fulfilling these requirements? His answer is, "I believe I can," and time must alone tell with what correctness this reply has been made, but I should consider him a man most unlikely to commit himself by a rash promise or on insufficient grounds. Failure in this case would be no argument whatever against the general value of his powder. I have referred to this sought-for *motor* principally to prove the great importance which Frenchmen of science attach to the capabilities of both Captain Schultze and his invention, without attaching any value to it whatever in connection with the more legitimate purpose of the latter.

If I have been rightly understood in this necessarily most incomplete and imperfect paper, the claims for Captain Schultze's invention principally rest on the following grounds :—

1st. Safety and rapidity of manufacture, and consequent reduction of cost. 2nd. Safety in transport and storage. 3rd. Less injury by absorption of damp, first, because the imbibed humidity, up to 3 per cent. is not injurious to its propulsive powers; and secondly, because, if even 10 per cent. of water be added, no mischief has accrued if the powder be re-dried. [Mr. Dougall here burned the powder, which he had previously saturated with water. It exploded, without the slightest apparent diminution of force.] 4th. Great diminution of recoil. 5th. Ample driving force. 6th. The power of almost indefinitely governing its rending force, so as on the one hand to adapt it for immense charges for cannon, or other fire-arms, without bursting; on the other hand, to increase that rending force up to the effect which I have faintly endeavoured to describe, as exemplified by explosion under water. 7th. Remarkable adaptability to breech-loading fire-arms for the most obvious of reasons, viz., absence of fouling. One of the tests at Spandau was to attempt to foul a Dreyse needle-gun by repeated firing, no difficult task, any one would say, who knows the construction of that weapon. But after 460 rounds, the gun remained clean, and the superintending officer then ordered the firing to cease. A somewhat similar result took place at Vincennes, with the Chassepot.

I have thus, Mr. Chairman, endeavoured to give perhaps in a somewhat desultory manner, a sketch of the history, manufacture, and present position of this new explosive. I trust that I have said enough to elicit discussion, and to engage your future attention to its qualities and career. I make no foolish or arrogant claims for it. To succeed, it has much work to do, many difficulties and prejudices to overcome. I shall therefore finish this paper by reading to you the several objections, raised some time ago, *in the most authoritative quarter*, and my replies, as taken from Captain Schultze's own lips, and immediately converted into plain English.

1st Objection. That the Schultze powder can be exploded by the blow of a hammer on iron.

Answer. That the Schultze powder may possibly be ignited by the blow of a hammer is a quality also possessed in like degree by black powder. The first authorities state that black powder "may be fired by the electric spark, and by percussion." This common quality has come under Captain Schultze's notice in his official capacity again and again, and he is prepared to demonstrate it at any time. Practically, the objection is invalid against either powder, because the conditions of ignition by percussion are such as are impossible of occurrence in storage, transport, &c., but so far as it goes, it in no degree whatever can be advanced against the Schultze powder as differing from black powder. They stand alike in this quality, as opposed to combinations of phosphorus, chlorate of potassium, and such like, which are capable of ignition under common and probable conditions. Whatever test, therefore, may be proposed, Captain Schultze is prepared to show will demonstrate the entirely similar qualities of the two varieties of powder, while, practically, he considers them valid against neither.

2nd Objection. That it is capable of absorbing moisture to the degree of 6 per cent. in twenty-four hours (I presume during an average state of the atmosphere).

Answer. That the Schultze powder is capable of absorbing 6 per cent. of moisture in twenty-four hours is not consistent with fact under the most trying conditions to which it has been submitted, the results of which gave an average of something under 3 per cent., so that in this respect it stands nearly on an equality with black powder, but with one very great difference in final results. While the hygrometric qualities are about equal, the effects of that absorption of moisture are very different, and all in favour of the Schultze powder, from this plain reason, that the combustion evolves gases which Captain Schultze has desired to retain by not charring his wood, and thereby depriving it of all hydrogen, which he actually utilizes in combustion. Captain Schultze does not assert that he desires an addition to the hydrogen gas already existing in his powder, but he does assert that the absorption of moisture in question has not the same diminishing effect upon its propulsive powers as it would have upon those of black powder. This question has also been practically and satisfactorily settled by the Prussian Government, which caused to be placed in the dampest casemate that could be found five barrels of each powder. After six months both were carefully tested by weighing and firing. The hygrometric tests were slightly in favour of the black powder, the actual absorption being of it as 2·20 to 2·80 of the Schultze powder, but the tests by firing were enormously in favour of the Schultze powder. The result of the exposure to damp for six months had reduced the propulsive powers of

The black powder	$8\frac{1}{2}$ per cent.
The Schultze powder	$4\frac{1}{4}$,,

These results are on record at Berlin, and the chemical causes of this superiority of the Schultze powder are perfectly understood.

3rd Objection. That its strength is modified by compression.

Answer. That compression exercises any special or peculiar influence on the powers of the Schultze powder is denied *in toto*. The common fact that it is proper to ram the powder well home in a gun is equally shared by black powder, if, indeed, it be not much more absolutely necessary in the latter to acquire equable powers of propulsion. Fantastic and nimious experiments of immense compression form no part of the question, and such pressure would alter of necessity the granular and other qualities of black powder in a much greater degree; in point of fact the objection is quite visionary. This answer is not theoretical, but founded on thorough experiments with both powders; these experiments are scientifically, but in no degree practically, interesting.

4th Objection. That it may be liable to self-combustion.

Answer. Decomposition, and consequently spontaneous combustion, are in the Schultze powder quite impossible. It may be stated here that during many years it was an especial task set to Captain Schultze by

the Prussian Government to test this among the other qualities of GUN-COTTON. He had every possible means at command, and exhausted the question. He is, therefore, enabled to assert, most authoritatively and without the slightest fear of valid contradiction, that while gun-cotton, by its organic construction, is highly susceptible of decomposition with all its evil results, in his powder it is a physical impossibility.

5th and last objection, that the different kinds of powder sent to England in 1865, 1866, and 1867, were not of uniform strength.

Answer. The difference in the powders sent to England in 1865, 1866, and 1867, arose solely from variations in the orders sent from that country. Any given standard can be absolutely maintained, and the objection is valid in no degree whatever; it would be quite as valid to object to black powder, that it is daily made of different sizes and qualities as ordered. The size of the grain and other conditions of the Schultze powder are simple matters of detail. It may almost be superfluous to state, in explanation, that German sportsmen use guns and shot differing in dimensions from those in use in England, and it is quite as easy to regulate the Schultze powder for the smaller sizes of shot, and wider calibre guns used in England, as it is for the English powder manufacturers to make it of various grains extending over six sizes, for muzzle-loaders, breech-loaders, and for rifles. For instance, an equivalent Schultze powder to No. 3 black powder, or any other size, can be absolutely maintained.

It may be added, generally, that all these objections are exactly those which of necessity presented themselves to Captain Schultze's own mind in the first instance, but which have in every case been so disproved by experience in Germany, that he almost feels it idle to repel them now. Their being raised in England is, however, perfectly natural, and he is prepared to discuss or disprove them practically, if desired. As a practical gunpowder maker, a chemist, and an artillery officer, there is no part of the whole subject which has not engaged his attention. He has succeeded in his purpose—to produce an explosive material to meet the requirements of the age; and, above all, as a source of personal gratification, the manufacture of which is not attended by the slightest risk of property, or of human life.

General BOILEAU, F.R.S.: I believe there is a gentleman in the room who has experimented with Schultze's powder. I allude to Mr. Lang, perhaps he will favour us with the results of his experiments.

Mr. LANG: I have generally found the samples vary, and I have not been able to carry out the experiments as I could have wished.

General BOILEAU: It appears to me that the paper which has been read this evening exhausts the subject, and leaves really little room for more remarks: I can, therefore, say very little upon the question as regards the details which have been laid before us. But there is one point on which it occurs to me that a word or two might be said. It has been for a long time urged as a reproach against chemical science, that while almost all manufactures—with very few exceptions, I believe—in the whole circle of the arts have benefited by our progress in knowledge, gunpowder has not so benefited; and at the present day it is made from the same ingredients, almost in the same proportions, as when first discovered nearly six centuries ago. I think, however, we may conclude, from what we have heard this evening, that the reproach is about to be removed, if it has not been removed already; and that if we cannot take it for granted that Schultze's powder is in a

condition, at present, to be generally used with the same confidence as black gunpowder is, the foundation for its future improvement has been laid, and we may look forward before long to the introduction of this new explosive agent with the same confidence, and with very much greater facilities of application, than in the powder which at the present time is used, both for sporting and military purposes.

Mr. LAMONT, M.P.: As a sportsman of some experience in different parts of the world, I wish to take this opportunity of mentioning, that since the month of October last, I have used this gunpowder at the recommendation of my friend, Mr. Dougall, nearly every day and with the utmost satisfaction, comfort, and pleasure. I have shot out of a common fowling-piece—12-bore—and I have no hesitation in saying, that the new powder will carry as far as black gunpowder. It makes very little smoke, very little noise, and with a total absence of recoil. Beyond that, I can only say that I think a great deal depends upon the way in which the cartridges are made, and especially upon the ramming.

The CHAIRMAN: As nobody else seems inclined to address the meeting, I shall close this discussion, because there is another subject to be brought before you by Mr. Read. He has made some lights which he wishes to exhibit. I think it is a matter of regret that Captain Schultze has not been able to be present himself to-night; still, I think, he has had a very able exponent of his gunpowder. Mr. Dougall has done full justice to the subject. It is certainly one of very great interest. I hope it will be taken up in this country, and that we shall hear of some experiments being made here, as well as in Prussia and France. I have not heard from Mr. Dougall whether any official experiments have been made here. I presume they have not.

Mr. DOUGALL: The powder has not yet been brought before the British Government.

The CHAIRMAN: I hope it may be.

Mr. DOUGALL: I have received a general order from the Lords of the Admiralty for testing, but nothing has been gone into at present.

The CHAIRMAN: I have no doubt, that if it is tested at all, it will be very carefully tested; for I rather think there is a Committee appointed to investigate the whole question of gunpowder and other explosive compounds, with the view of their being brought into practical use. I will now conclude with proposing a vote of thanks to Mr. Dougall for having read this paper to us.

Mr. DOUGALL: I am much obliged to you, Gentlemen, for the patience with which you have heard my paper, and also to Mr. Lamont, so distinguished a sportsman and Member of Parliament, for kindly coming forward and testifying to its qualities. I may state as a tangible proof of the excellence of this powder, that to-day I received from Mr. Lamont an order for gunpowder, for his use during the shooting season, four times greater in quantity than any order I have ever received during my long experience as a gun-maker.

Mr. STIRLING LACON: Black gunpowder or Schultze's powder?

Mr. DOUGALL: Schultze's powder.

HELM-INDICATOR, FOR THE PREVENTION OF COLLISIONS AT SEA.*

By Mr. George Read, R.N.

In the model of a steamer before you, is shown the manner by which the motion of the wheel, or tiller, can be made known to a ship approaching, even at the distance of three or more miles, by day or night.

A rope or chain is rove through a block, or cheek, at the masthead, from thence to a block hooked on the ship's side, and laid along the top rail or water ways through a tube to a block abreast of the wheel or tiller; the turns are passed under and over the barrel of the wheel, or to the end of the tiller if the rope or chain is placed on the barrel of the wheel. It takes two turns of the wheel to place the helm hard to starboard. If the circumference of the barrel be 14 inches, the light will be drawn up the tube 2 feet 4 inches, so that the hoist of the light can be regulated by the circumference of the barrel of the wheel or the length of the tiller.

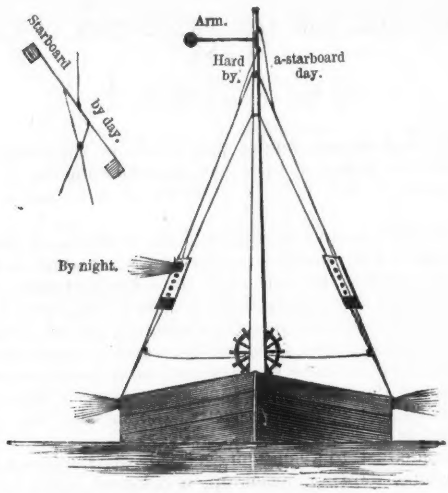
A line is made fast to a lamp on each side of the vessel, and this is drawn up a tube, showing, when up, a coloured light, corresponding with the present regulation light, so that whichever way the helm is put, two lights of the same colour will be shown.

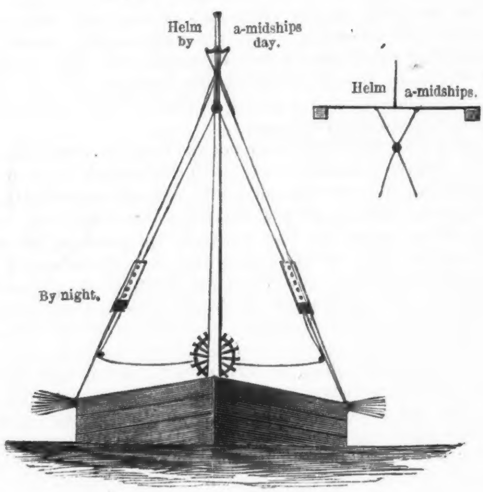
The tube may be made of metal or wood, with an open front sufficient to show the same ray of light as the present regulation light. Holes are made in the after-part of the tube, with a view to show the officer of the watch what the man at the wheel is doing. The bottom of the tube forms a box to shelter the light when not in use; a brush can be placed inside of the front to remove salt water spray, &c. The lamp-box has a spring at the bottom, to prevent sudden concussion on the wheel flying round.

If the helm is put the wrong way, as is often the case, the officer in charge of the ship will be able to check the helmsman in an instant, and a ship approaching will see the same, and will act accordingly, and will do what judgment says is proper, for her commander will know that the officer is either undecided how to act, or the man at the wheel has misunderstood the order, and put the helm to port instead of to starboard. Should the man at the wheel be steering the ship wildly, the light will appear as if jumping from hole to hole, and should he fall asleep the light will remain stationary and show that the ship is going off her course.

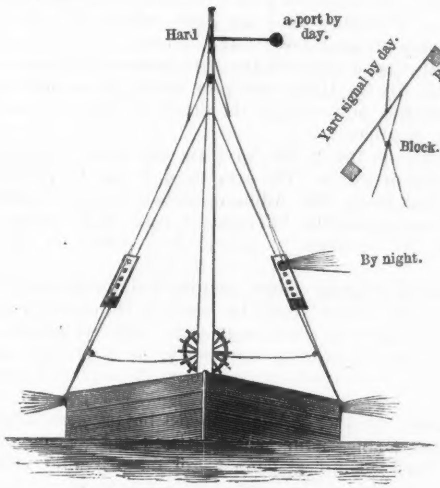
There is a great advantage in having aft-holes in the tube, as the man at the wheel can thus see whether his helm lamp is burning brightly or not, and a ship coming up to another on the quarter will have sufficient light from the after part of the tube to know that the ship he is running up to, has starboarded or ported his helm to get out of his way.

* The helm-indicator and the apparatus for pier-heads, &c., are the joint inventions of Messrs. Read and Nunn.—Ed.


Starboard
by day.
Arm.
Hard
by.
a-starboard
day.
By night.


Helm
by
a-midships
day.
Helm
a-midships.
By night.

For day signals, a yard is slung by the centre as represented on the fore and mizen masts, with a line on each quarter to top it in a vertical position when the wheel is set in motion. The yard-arm has a *green* and *red* flag, one at each end, or a *green* and *red ball*. If the helm be put to starboard, the green flag or ball will be *up*, and the red *down;* if port, red *up* and green *down*.



The apparatus is so simple that any cabin-boy can rig or repair it when out of order.

By the use of this apparatus all speculation as to which side a ship will pass another is at an end. Should a collision take place between ships with this apparatus on board, it will show what party was in the wrong, and must do away with much hard swearing in the Admiralty Court, as the colour of the helm-light will be clearly visible and a note taken of it at the time of the collision—a most important thing—and no man can go into court and swear that *red* is *green*, or green is red, when there will be *two lights* of *one colour for* or *against* him. If A runs into B with starboard helm there will be two green lights and one red, if B ports his helm to clear A there will be two red lights and one green. No man can tamper with these lights, or can they be moved except by the man at the wheel, for it is only by moving the wheel that the lights can be set in motion; the wheel must revolve back the starboard turns to let the port come on.

The arm at the maintopmast head will be worked for a day signal, and can be made to work the lights also. If the helm be amidships, the arm will be perpendicular, if hard a-starboard, it will be horizontal to

the right of the ship, or starboard side, if port it will be to the left or port side. It can also be applied in a fog to touch two springs to strike a *gong* for starboard and a *bell* for port, as the end of the arm will be constantly in motion from *starboard* to *port*.

In rivers and roadsteads also the Helm-Indicator will be valuable for preventing collisions. The helm is generally lashed port or starboard, if *port*, the cable will be on the port bow, and a ship can then swing out of her position by starboarding her helm, which will shear her out of the way of a ship drifting down with the tide.

The use of this apparatus will also give a vessel a chance of anchoring in a clear berth. By the Helm-Indicator will be known the true position of the ship's anchor, according to the depth of water she is riding in, to a few fathoms of cable.

In naval tactics in the Royal Navy the use of the helm-indicator will be useful for day or night. The arm by day can be placed on a dial, similar to a clock face; the Admiral with a powerful glass would be able to see in an instant the difference of each ship's wheel under sail, and a note could be made of every ship's wheel in the fleet, to a spoke.

When engaged with an enemy, and the hull enveloped in smoke, the true motion of the rudder could be seen at the fore, main, or mizen royal truck. Tacking in succession ships will be able to follow one another during the night very accurately, as I propose to connect a trigger line to fire a gun, when the helm shall be placed extreme either way.

The apparatus, when complete, will cost but a mere trifle, and there will be no extra labour to the man at the wheel, as the gear aloft is equipoised. Once placed, it cannot get out of order more than the ordinary gear of a ship. The lights can be placed on any part of a ship, on a stanchion or outrigger, clear of all square sails.

APPARATUS FOR LIGHT VESSELS, TIDAL HARBOURS, DOCK HEADS, PIER HEADS, &c.

This apparatus, very similar to that I have just described, I propose to use in conjunction with the helm-indicator, to be placed on board light vessels at pier-heads, &c. The light keeper will see by the ship's indicator whether she is steering towards a dangerous part of the sands or not. Should such be the case, such a ship could be guided into safety by him. He would fire a gun, send up a rocket, and then show the helm signals, *starboard* or *port*, to the ship so running into danger. I am not aware that, at the present time, light keepers have any means of signalling to a ship. Many vessels are seen running along the edge of a sand with a dangerous spit ahead, that must certainly pick the ship up if she is allowed to keep her course.

The primitive way of signalling ships into tidal harbours such as

Dover, &c., is, by day, to swing an old hat right or left; by night, a lanthorn is swung, and that often in a line with the street lamps.

With my apparatus the deputy harbour-master has only to move the lever. If he wishes the ship to go more to the right, he has only to put the handle *right;* if *left*, to put the handle *left;* if straight ahead, put the handle up along the mast, and whatever the signal from the shore is, the ship, with her indicator, will do likewise, and then no mistake can be made.

Should my apparatus be adopted, any stranger could run for any harbour, without a pilot, with the greatest confidence. The deputy harbour-master knows the strength of the tide in such a harbour, and his judgment would be far superior to that of any one in charge of the ship. He looks over the pier-heads and sees the face of the current passing, and is able to make the allowance accordingly.

Commander COLOMB, R.N.: The lecturer, I think, deserves very great credit for the complete manner in which he has carried out his idea of a helm-indicator. I have seen three or four plans of that nature, and this one is certainly more perfectly carried out, in all respects, than any I have yet seen. There is no doubt, whatever, that if you have a means of indicating to an observer outside a ship, the state of the helm of that ship, you will go a certain length towards avoiding collisions; but only a certain length, because in eight collisions out of ten, the motion of the ship in the day-time, or a change from red to green or from green to red at night, does indicate a change of course either to port or to starboard. But that change of course is not generally taken advantage of as I think it ought to be. On the other hand, I may say that changes of course are often surmised where really they do not occur. Ships crossing the line of keel of another ship very often imagine that the change of colour in the lights means an alteration in the helm, when, in reality, it means no such change. Now, with such a plan as the present—supposing it can be practically carried out—we should get rid of that danger. But I think there is this to be said, that what one really does want most for the avoidance of collisions, is not a registry of the movement of the helm, so much as an expression of the intention of the person in charge of the ship. That we do not quite get in this plan, because the helm may be put one way and then altered again. However, as I said before it is a very complete plan, and it does the proposer very great credit indeed.

The CHAIRMAN: If no gentleman wishes to make any further remarks, I will, in your names thank Mr. Read for the very ingenious apparatus he has brought before us. We are all aware, at least all those who navigate ships, that it is a great desideratum to be able to know what the ship you are meeting is about to do. If you could always be quite certain that she would put her helm the right way, then, I think, that many collisions, that now take place, would be avoided. Any one who has seen the small river boats that navigate the Thames, will probably have noticed, that in meeting each other, though they do not, perhaps, observe what is technically called "the rule of the road," the captains hold out their arms, so as to indicate what they are doing, thus showlng exactly which way each helm is put. I am quite sure that many collisions would be avoided if we had some simple apparatus, such as Mr. Read has brought before us, to indicate what a ship meeting another ship is going to do. I now, in your names, gentlemen, thank Mr. Read for the explanation he has given of his very ingenious apparatus.
